SILVER LAKE

1993
LAKES LAY MONITORING PROGRAM

by
Jeffrey A. Schloss
Robert K. Craycraft

edited by
A.L. Baker and J.F. Haney

NEW HAMPSHIRE LAKES LAY MONITORING PROGRAM

NH LLMP

FRESHWATER BIOLOGY GROUP
University of New Hampshire
Durham

UNIVERSITY OF NEW HAMPSHIRE
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To obtain more information about the NH Lakes Lay Monitoring Program (NH LLMP) contact the Coordinator (J.Schloss) at (603) 862-3848
Dr. Baker at 862-3845 or Dr. Haney at 862-2106

PARAMETERS SAMPLED
NH LAKES LAY MONITORING PROGRAM

- LAY MONITORS
  - BASIC PROGRAM
    - Secchi Disk Depth
    - Temperature Profile
    - Chlorophyll a
    - Dissolved Color
  - ADVANCED OPTIONS
    - Total Phosphorus
    - Total Alkalinity
    - pH
    - Metalimnetic Chl a
    - Fish Condition
    - Aquatic Vegetation
    - Rainfall & pH
    - Motorboat Effects
    - Bacteria
  - STREAM MONITORING
    - Obs. Survey
    - Temperature
    - Conductivity
    - Total Alkalinity
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    - Stream Flow
    - Macro-Invertebrates
    - Storm Events
    - Bacteria

FBG Team corraborate tests above and sample plankton

PREFACE

This report contains the findings of a water quality survey of Silver Lake, Madison, New Hampshire, conducted in the summer of 1993 by the **Freshwater Biology Group (FBG)** of the University of New Hampshire and the Silver Lake Association.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1993 results as well as more detailed "Introduction" and "Discussion" sections. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

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ACKNOWLEDGEMENTS

1993 marked the eleventh year of participation in the **Lakes Lay Monitoring Program (LLMP)** for the Silver Lake monitors. The Lay Monitors of Silver Lake were Bob Benford, Ed and Pat Blackey, Pricilla Furse, Bruce Gordon, Charlotte Hill, Frannie Kennett, Robert Newton and Pomeroy. Bruce Gordon and Bob Benford coordinated the volunteer monitoring efforts on Silver Lake and acted as liaisons to the **FBG**. The **FBG** congratulates the Lay Monitors on the quality of their work, and the time and effort put forth. We encourage other interested members of the Silver Lake Association to join the monitoring effort in 1994. Funding for the monitoring program was provided by the Silver Lake Association.

The **Freshwater Biology Group** is a not-for-profit research program co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the **FBG** summer field team included Roy Clark, Robert Craycraft (who assisted in the coordination of the **FBG**), Amanda Jamison, Gregory O'Neil, Sean Proll and Jeffrey Schloss. Other **FBG** staff assisting in the fall included Jessica Chappel, Steven Meyer and Marjorie Steele.

The **FBG** acknowledges the University of New Hampshire Cooperative Extension for funding and furnishing office, laboratory and storage space. The College of Life Sciences and Agriculture provided accounting support and the UNH Office of Computer Services provided computer time and data storage allocations.

Participating groups in the **LLMP** include: The Center Harbor Bay Conservation Commission, Derry Conservation Commission, Dublin Garden Club, Governor's Island Club Inc., Little Island Pond Rod and Gun Club, Meredith Bay Rotary Club, Nashua Regional Planning Commission, The New Hampshire Audubon Society, Society for Protection of Lakes and Streams, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Beaver Lake, Berry Bay, Big

Island Pond, Bow Lake Camp Owners, Chalk Pond, Chesham Pond, Lake Chocorua, Cunningham Pond, Crystal Lake, Dublin Lake, Glines Island, Goose Pond, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Lovell Lake, March's Pond, Mascoma Lake, Mendum's Pond, Merrymeeting Lake, Milton Ponds Lake Lay Monitoring, Mirror Lake (Tuftonboro), Moultonbouro Bay, Lake Winnipesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Pea Porridge Pond, Pemaquid Watershed, Perkins Pond, Pleasant Lake, Silver Lake (Hollis), Silver Lake (Harrisville), Silver Lake (Madison), Silver Lake (Tilton), Squam Lakes, Lake Sunapee, Sunset Lake, Lake Waukewan, Lake Winona, Wentworth Lake and the towns of Alton, Amherst, Enfield, Errol, Hollis, Madison, Meredith, Merrimack, Milan, Strafford and Wolfeboro.

SILVER LAKE (MADISON)

1993 NON-TECHNICAL SUMMARY

Weekly monitoring of Silver Lake was undertaken by the volunteer monitors from June 25 through September 21, 1993 while a more in-depth analysis of Sites 2 Deep, 5 North and 7 North Island was undertaken on August 25, to more completely assess the condition of Silver Lake. The following section summarizes the 1993 water quality conditions for Silver Lake and when applicable, incorporates historical data into the interpretation.

1) Water transparency at Silver Lake was again high, the sign of a clear and unproductive lake. The seasonal high Secchi Disk readings were near the record transparency highs (since the initiation of **LLMP** participation in 1983) for all Silver Lake sampling stations: 1 South (9.5 meters), 2 Deep (9.0 meters), 3 Center (9.4 meters), 4 East (6.0 meters), 5 North (9.4 meters) and 7 North Island (7.5 meters). New seasonal average water transparency highs were established at the 1 South (7.7 meters), the 2 Deep (7.6 meters) and the 5 North (7.4 meters) sampling stations while the seasonal average Secchi Disk transparencies were near historical levels at Sites 3 Center (7.6 meters), 4 East (5.8 meters) and 7 North Island (6.7 meters). Refer to figures 29, 31, 33, 35, 37 and 39 for a visual representation of current and historical Secchi Disk transparency trends. All 1993 Secchi Disk transparency measurements remained above 4.0 meters which is considered the boundary between an unproductive and moderately productive lake (i.e. the Secchi Disk transparency readings are indicative of an unproductive, New Hampshire, Lake). The extremely high Secchi Disk transparencies measured during the 1993 sampling season are likely a response to the atypically dry summer, which minimized sediment, dissolved color and nutrient loadings, all of which can adversely affect water clarity readings.

2) Chlorophyll *a* concentrations (a measure of microscopic plant abundance) for the surface waters of Silver Lake were low. Seasonal average Chlorophyll *a* concentrations were near historical minima at the six sites sampled. Refer to figures 30, 32, 34, 36, 38 and 40 for a visual representation of current and historical chlorophyll *a* trends. The chlorophyll *a* concentrations in the mixed layer of water, collected by the volunteer monitors, averaged 1.0 milligrams per cubic meter (1.0 mg m^{-3} equivalent 1.0 parts chlorophyll per billion parts water) at Site 1 South, 0.9 mg m^{-3} at site 2 Deep, 1.0 mg m^{-3} at Site 3 Center, 1.1 mg m^{-3} at Site 4 East, 1.2 mg m^{-3} at Site 5 North and 1.3 mg m^{-3} at Site 7 North Island. Concentrations below 3 mg m^{-3} are common to less productive, clear, lakes while values in excess of 7 mg m^{-3} are common to productive lakes. Chlorophyll *a* concentrations between 3 mg m^{-3} and 7 mg m^{-3} are considered indicative of intermediate productivity. While chlorophyll *a* concentrations remain low, the Northern sampling stations (5 North and 7 North Island) continue to exhibit elevated algal (chlorophyll *a*) productivity, relative to the southern sampling stations.

3) Dissolved lakewater color levels for Silver Lake were low, 17.4 platinate color units (ptu), and less than the average of 23 (ptu) for **LLMP** program lakes. Small increases in water color from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality. However, increased color can lower water transparency, and hence, change the public perception of water quality. Large amounts of dissolved color may occur naturally but also occur during deforestation and development within the watershed. High color levels can actually mask the ability of the Secchi Disk transparency to predict chlorophyll levels. With the minimal rainfall in the summer of 1993, watershed runoff was minimized, which in turn, reduced the flushing of highly "stained" waters into the lake.

4) Total phosphorus (nutrient) samples, collected by the Lay Monitors and **FBG**, were low in the surface waters with a range of 2.2 ppb to 6.6 ppb during the 1993 sampling

season. Elevated phosphorus concentrations were noted in the hypolimnetic (bottom) waters of Site 7 North Island, 18.6 ppb to 30.6 ppb, and in the Forest Brook Inlet, 8.2 to 13.5 ppb. The elevated phosphorus concentrations in the hypolimnion of the North Island sampling station are well in excess of 15 ppb, which is commonly thought of as the boundary between moderately and highly productive lakes, and likely contributes to algal growth late in the season when thermal stratification is disrupted and nutrients circulate throughout the water column. Refer to Appendix A for a complete listing of the 1993 phosphorus data for Silver Lake.

5) The pH of the surface waters of Silver Lake, measured by the **FBG** (range: 6.4 to 6.8), remains within the optimum range for most aquatic organisms. The alkalinity of the lake (a measurement of the lake's resistance to acidification) is low, 4.0 units, and about 2.0 units lower than the average alkalinity of 6.3 units for **LLMP** program lakes. However, alkalinity levels, averaged for the season, are about one-half unit higher than the 1992 average. Thus, while alkalinity levels are low, they increased slightly during the dry summer season of 1993 during which acid loadings were minimized.

6) The specific conductivity of the deepwater sites on Silver Lake was low, with a range of 32.0 to 54.0 micro-Siemans. High conductivity values can be associated with septic leachate, road salt runoff or sedimentation into the lake and can thus, screen for potential problem areas in and around the lake. The highest conductivity levels were recorded at the 7 North Island sampling station and increased towards the lakebottom. Elevated phosphorus and alkalinity levels, which were measured in the hypolimnion, indicate nutrient accumulation in the deeper waters.

7) In-depth analysis at the deep sites disclosed the typical temperature stratification patterns for northern temperate lakes. With the depth of the upper mixed layer of water extending to 6.5 meters. The oxygen content of the bottom waters remained above 5

milligrams per liter (the minimum concentration required for successful reproduction and growth of most coldwater fish) throughout the water column for Sites 2 Deep and 5 North, while the oxygen concentration remained above 5 milligrams per liter only down to about 8.5 meters at Site 7 North Island (see figure 26). In addition, high carbon dioxide concentrations (a by product of microbial respiration) were measured at the latter site, which suggest the accumulation of organic matter from both internal (i.e. plant and algal productivity) and external (i.e. leaf litter and grass clippings) sources.

8) For all measurements considered and averaged for the season, Silver Lake would be classified as a clear and unproductive, oligotrophic, lake. However, the northern sites (particularly Site 7 North Island), demonstrate a higher level of productivity than the southern sampling stations. Future sampling should be directed at locating potential problem areas in the watershed. Both visual observation, as well as tributary sampling, will be useful in identifying areas of concern.

9) Comparisons between Lay Monitor and **FBG** data indicate that the volunteer monitors of Silver Lake are doing an excellent job of measuring water quality at all sampling stations. Alkalinity readings recorded by the **FBG** are about 1 unit lower than the alkalinity readings recorded by the Silver Lake monitor.

COMMENTS AND RECOMMENDATIONS

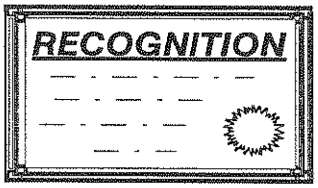
1) We recommend that each participating association, including the Silver Lake Association, continue to develop its data base on lake water quality through the continuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and will eventually enable more reliable predictions of water quality trends.

2) Changing land use within your watershed, the surrounding land which drains into the lake, can accelerate the natural aging process. A lake typically fills in and becomes more productive on a geological time frame (thousands of years), however, this process can be accelerated to occur in tens of years when development, agriculture and other landscape changes occur that do not incorporate the best management practices (i.e. maintaining vegetative buffer strips along the shoreline, minimizing fertilizer and pesticide applications, installing proper erosion control structures, etc.) set to minimize water quality impacts. We invite interested persons to take part in a new assessment manual, produced jointly by the **UNH LLMP** and the New Hampshire Soil Conservation Service (NH SCS), which provides the layperson with a systematic method for recognizing and evaluating erosion, sedimentation and related non-point source (NPS) pollutant problems in New Hampshire watersheds. Contact the **LLMP** coordinator for further information.

3) We invite other interested residents to join the monitoring effort on the Silver Lake. The **LLMP** will provide an initial training session to review lake monitoring methodologies and help modify the monitoring program, if desired, to meet the current concerns of the Silver Lake Association. Those interested in monitoring should contact Jeff Schloss, **LLMP** Coordinator, or Bob Craycraft, Assistant **LLMP** Coordinator:

AWARDS

and



1983- N H Environmental Law Council
1984- Governor's Volunteerism Award
1985- CNN Science & Technology Today
1988- Governor's "Gift" request funded
1990- New Hampshire Journal on PBS
1991- Renew America Success Award
- Environmental Success Index
- UN Environmental Programme
- Soviet Embassy Reception
- White House Environment Briefing

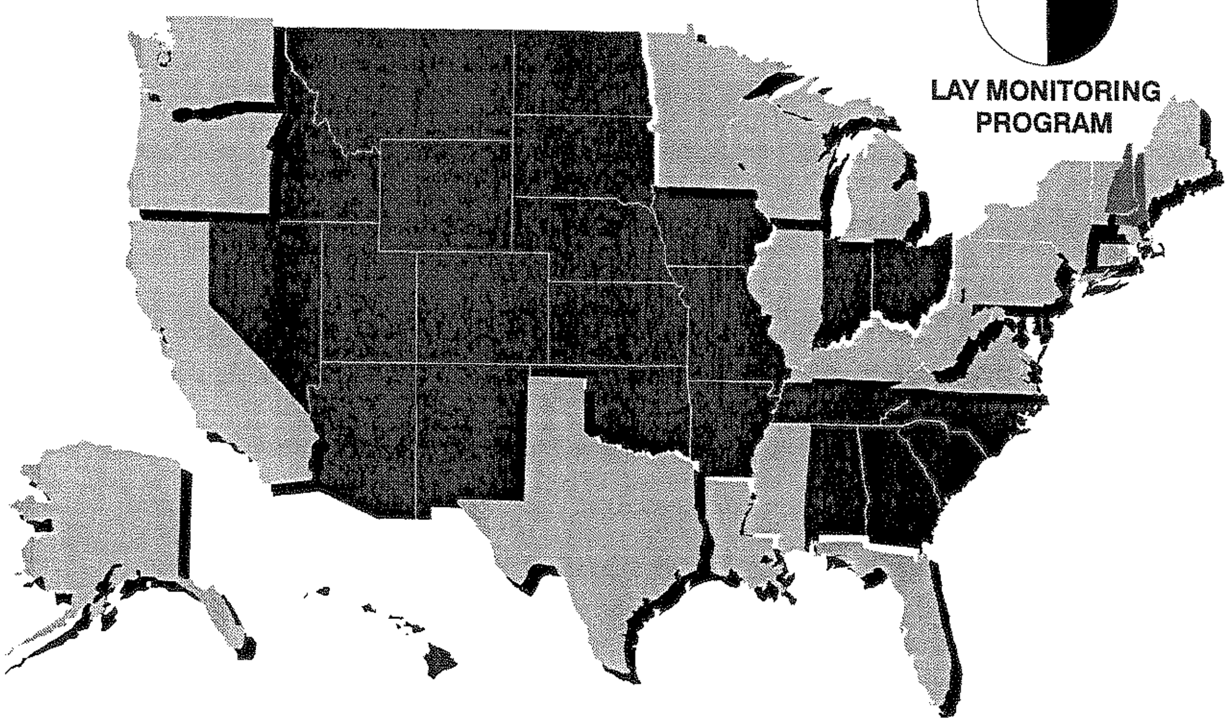
1992- EPA Administrators Award
- Environmental Exchange Network

1993- NH Lakes Association

NH LLMP Directly Involved with the Initiation, Expansion or Support of Volunteer Programs in 22 States.

NH LAKES

LAY MONITORING PROGRAM



INTRODUCTION

The New Hampshire Lakes Lay Monitoring Program

In this sixteenth year of operation, the **NH Lakes Lay Monitoring Program** has grown from a university class project on Chocorua Lake and pilot study on the Squam Lakes to a comprehensive state-wide program with over 500 volunteer monitors and more than 100 participating lakes. Originally developed to establish a data-base for determining long-term trends of lake water quality for science and management, the program has expanded by taking advantage of the many resources that citizen monitors can provide. The **NH LLMP** has an international reputation as a successful cooperative monitoring, education and research program. Current projects include: use of volunteer generated data for non-point pollution studies using high tech analysis system (Geographic Information Systems and Satellite Remote Sensing), intensive watershed monitoring for the development of lake nutrient budgets, and investigations of water quality and indicator organisms (food web analysis, fish condition, and stream invertebrates). The key ingredients responsible for the success of the program include innovative funding and cost reduction, assurance of credible data, practical sampling protocols and, most importantly, the interest and motivation of our volunteer monitors.

The 1993 sampling season was another exciting year for the **New Hampshire Lakes Lay Monitoring Program**. National recognition for the high quality of work by you, the volunteer monitors, continued with awards, requests for program information and invitations to speak at national conferences. We continue to be listed as a model citizen monitoring program on the Environmental Success Index of Renew America and on the Environmental Network Clearinghouse. To date, the approach and methods of the **NH LLMP** have been adopted by new or existing programs in twenty two states and nine countries!

The General Scenario - 1993

The Winter of 1992-93 was off to a white start with several major snowstorms occurring in the early months. The accumulated snowpack in many areas resulted in considerable runoff in late March and early April during the spring snowmelt. For those lakes which were monitored early enough, the winter conditions translated into lower alkalinities (buffering capacity) and lower pH levels in the tributary streams and in some lakes, when compared to results from a few years back; years with little snow pack. Thus, while many lakes have had steady or even increasing buffering levels for the last few years, a more typical (in terms of what was "normal" for New Hampshire in the last 30 years) snowfall amount this winter indicates that acid rain should still be one of our concerns.

The spring and summer months proved to be dry, once again (1993 was one of the driest summers in the past decade). This generally minimized sediment and nutrient runoff from the surrounding watershed and resulted in continued optimum water quality conditions for most participating **LLMP** lakes. In fact, several lakes recorded record high water clarity (secchi transparency) in 1993.

Lakes were clearer due to a combination of factors that once again included lower dissolved color compounds (dissolved organic matter from the breakdown of vegetation and soils) washed in from surrounding wetland areas, lower algae growth (measured as chlorophyll *a*) in the surface waters, due to lower nutrient runoff, and lower suspended sediment levels. Dissolved water color is not indicative of water quality problems (although large increases in dissolved color sometimes follow large land clearing operations) but in some of our more pristine program lakes, it nevertheless has a large effect on water clarity changes.

As with dissolved color and nutrients, the dry spring and summer season brought less suspended sediment load to many of our streams and lakes. If increased clarity was not the result of decreased dissolved color or chlorophyll *a* levels than it was due to decreased suspended sediment by default. To find out how these water quality indicators inter-relate for your particular lake site, compare the Secchi Disk, chlorophyll *a* and dissolved color graphs enclosed in this report (see figures 4 through 21). Note whether changes in clarity (Secchi Disk depth) correspond to chlorophyll *a* or dissolved color concentration changes or whether it is a combination of the two. If neither seem to exhibit a consistent effect, then suspended sediment likely plays an important role in your lake's clarity.

In addition to limited watershed runoff, the hot and dry weather conditions in the early part of the summer resulted in a low water table. This sometimes translates into less of a chance of septic system failure; minimizing algae and some aquatic plant growth by further limiting nutrient loading. However, some lakes did experience increased aquatic plant and/or algae growth in 1993 which could be the result of a variety of factors: a lower water level and thus a greater surface area exposed to penetrating light (for photosynthesis) occurring simultaneously with a large number of clear and sunny days, as well as warmer water temperatures (conducive to plant growth). Longer water detention times and limited water movement was also a candidate for the elevated plant and algal growth in the shallows. Nutrients remained in the shallow shoreline areas during and following the minimal storm events which occurred and thus could be utilized for algal and plant growth in those localized regions.

In addition, several lakes experienced "algal blooms" late in the season. "Algal blooms" are often "green water events" associated with decreases in water clarity due to their ability to absorb and scatter light within the water column. Algal blooms can also accumulate at the lake bottom as "mats" or the water surface as "scums" and "clouds". All types of "algal blooms" were observed in several participating **LLMP** lakes in 1993. "Algal blooms" are naturally occurring phenomenon and are not necessarily associated with changes in lake productivity, although increases in the occurrence of "bloom" conditions can be a sign of eutrophication (the "greening" of a lake). Algal blooms of varied extent typically occur even in our most pristine lakes late in the fall and early in the spring as a result of lake mixing at those times.

In many lakes, particularly those within the Lakes Region of New Hampshire, cotton-candy like "clouds" of the nuisance green filamentous algae, *Mougeotia*, or a related species formed within the weed beds and then drifted freely into shallow areas around the lake. These algae often take advantage of nutrients that leak from particularly active submerged weeds or from bottom areas that have been disturbed by weed removal or other activities. While the summer of 1993 was in most cases a banner year for submerged aquatic plants (i.e. less plant growth), for reasons described above, there were many reports of these "blooms".

For some lakes, weather conditions became conducive to the formation of "blooms" of other algae species late in the season when the water temperatures were above average and several storm events following the extremely dry conditions flushed materials (sediment, dissolved color, nutrients) down through the watershed and into the lake. With this sudden inoculation of nutrients followed by improved lake flushing, these blooms tended to occur suddenly, but were generally short lived.

In other lakes, metalimnetic algae, algae which tend to grow in a thin layer along the thermocline gradient in a lake's middle depths, sometimes migrate up towards the lake surface causing a "bloom" event. Dry summers can result in substantial populations of these algae to develop well out of site of the observer (and even the Secchi Disk!) until they "decide" to surface. If these algae are predominantly "nuisance" forms, like certain green or blue-green algae, they can be an early indication nutrient loading.

The **LLMP** will continue to monitor "bloom" phenomenon in 1994 as it can be a sign of the changing land use practices and impacts within the lake watershed that can result in a long-term increase in lake productivity. However, it is possible that these phenomena were signs of short-term perturbations in water quality, the "noise" within the true long-term signal, induced by the atypical weather conditions of this past summer.

As in 1992, a few **NH LLMP** lakes were actually worse off during the 1993 sampling season. These lakes included those more productive lakes in which a good deal of nutrients come internally from sediment release. Lakes with significant nutrient input from septic systems or shoreline fertilization and watering would also have a bad year under the 1993 conditions. Other lakes that fared worse this year were seepage lakes, shallow lakes that rely on groundwater (springs) in-flow and out-flow for replenishment and cleansing. With a low water table, these lakes became great "growth chambers" for algae.

To see how your lake fared in 1993, relative to previous years of monitoring, refer to figures 29 through 40 in the back of this report.

Importance of Long-term Monitoring

A major goal of a monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For almost a decade and a half, data collected weekly from lakes participating in the **New Hampshire Lakes Lay Monitoring Program** have indicated there is quite a variation in water quality indicators through the open water season on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms or the lake response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

To determine if a change in water quality is occurring, a lake must be sampled on a frequent basis over a substantial amount of time. A poorly designed sampling program may even mislead the investigator away from the actual trend: Consider the hypothetical lake in Figure 1. Sampling only once a year during August from 1982 to 1986 would produce a plot (Fig. 2) suggesting a decrease in eutrophication. The actual long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling additional times a year for a ten year period (Fig. 1). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term trends ("signal"). To that end, the lake must establish a long-term data base.

The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data is collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose the location of specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a lay monitor in the **NH Lakes Lay Monitoring Program**. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next. Yet every sampling provides important information on the variability of the lake.

We are pleased with the interest and commitment of our Lay Monitors and are proud that their work is what makes the **NH LLMP** the most extensive, and we believe, the best volunteer program of its kind.

Purpose and Scope of This Study

1993 marked the eleventh year that monitoring of Silver Lake was undertaken by the **Freshwater Biology Group** and the Silver Lake Association. The program of sampling was designed to continue adding data to the long-term data base established. Sampling emphasis was placed on six deep, open water, sampling stations located on Silver Lake while additional tributary sampling of the Forest Brook tributary inlet was also undertaken. More in-depth monitoring of the deep sampling stations; 2 Deep, 5 North and 7 North Island, was undertaken by the **FBG** on August 25, 1993 to more fully assess the condition of Silver Lake.

The primary purpose of this report is to discuss results of the 1993 monitoring with emphasis on current conditions of Silver Lake including the extent of eutrophication and the lakes' susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for New Hampshire lakes that include New Hampshire Fish and Game surveys of the 1930's, the surveys by the New Hampshire Water Supply and Pollution Control Commission and the **FBG** surveys. Care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various testing facilities and technological improvements in testing.

DISCUSSION OF LAKE MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the **New Hampshire Lakes Lay Monitoring Program**. Where appropriate, summary statistics of 1993 results from all participating lakes are included. Certain tests or sampling performed at the time of the optional **Freshwater Biology Group** field trip are indicated by an asterisk (*).

Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions, characterized by a sharp drop in temperature with depth, is called the **thermocline** or **metalimnion**. Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion. Swain's Lake became stratified into three distinct thermal layers during most of the 1993 summer sampling season.

Silver Lake became stratified into three distinct thermal layers as the season progressed.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of Secchi Disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

In the shallow areas of many lakes, the Secchi Disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi Disk measurements are generally taken over the deepest sites of a lake. Transparency values of greater than 4 meters are typical of clear, less productive lakes. Values less than 2.5 meters are generally an indication of a very productive lake. In 1993 the average transparency for lakes participating in the **NH LLMP** was 5.6 meters with a range of 1.2 to 11.6 meters. Table 1 summarizes the current years Secchi Disk data from Silver Lake while a more complete listing of 1993 data is included in Appendix A of this report. Based on the 1993 and historical Secchi Disk data, Silver Lake would be considered a clear and unproductive, New Hampshire, Lake.

Table 1. 1993 Lay Monitor Secchi Disk Data comparison of Silver Lake.

Site	Trans-parency (m) Minimum	Trans-parency (m) Average	Trans-parency (m) Maximum	Sample Number
1 South	5.5	7.7	9.5	12
2 Deep	5.8	7.6	9.0	11
3 Center	5.8	7.6	9.4	11
4 East	5.4	5.8	6.0	11
5 North	5.5	7.4	9.4	12
7 NorthIs	4.5	6.7	7.5	11

Chlorophyll a

The chlorophyll *a* concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll *a* concentrations average above 7 mg m^{-3} (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll *a* concentrations are generally less than 3 mg m^{-3}. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout.

Mesotrophic lakes are intermediate in productivity with concentrations of chlorophyll *a* generally between 3 mg m^{-3} and 7 mg m^{-3}. In 1993 the average chlorophyll for lakes participating in the **NH LLMP** was 3.0 mg m^{-3} with a range of 0.1 to 43.7 mg m^{-3}. Table 2 summarizes the current years chlorophyll *a* data collected in Silver Lake while a more complete listing of 1993 data is included in Appendix A of this report. The 1993 and historical chlorophyll *a* data fall within the range typical of an unproductive, New Hampshire, lake.

Table 2. 1993 Lay Monitor Chlorophyll *a* Data comparison of Silver Lake.

Site	Chl *a* (ppb) Minimum	Chl *a* (ppb) Average	Chl *a* (ppb) Maximum	Sample Number
1 South	0.6	1.0	1.4	12
2 Deep	0.5	0.9	1.6	11
3 Center	0.4	1.0	1.7	12
4 East	0.3	1.1	2.3	11
5 North	0.8	1.2	2.1	12
7 NorthIs	0.9	1.3	1.8	11

Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentration of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. These populations should be monitored as they may be an indication of increased nutrient loading into the lake.

Mid-Lake chlorophyll *a* samples, collected by the **FBG**, indicate the presence of a stratifying layer of algae on the August 25 sampling date. The mid-lake chlorophyll *a* concentrations measured 5.3 mg m^{-3} at Site 2 Deep, 4.8 mg m^{-3} at Site 5 North and 2.7 mg m^{-3} at Site 7 North Island.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters. Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, both dissolved color and chlorophyll information is important when interpreting the Secchi Disk transparency.

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 15 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing phosphorus to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Sediment Erosion, Septic Systems, etc) will show greater concentrations of nutrients as the summer progresses or after major storm events. Circulation of nutrients from the bottom waters of more productive lakes in late fall can result in algal blooms.

Total phosphorus concentrations remained low in the surface waters of Silver Lake and ranged from 2.2 to 6.6 ppb. The highest in-lake phosphorus concentration, documented during the 1993 sampling season, was measured in the hypolimnion of the 7 North Island sampling station and is indicative of accumulating nutrients near the lakebottom.

pH *

The pH is a way of expressing the acidic level of lake water, and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (ie: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Surface water pH measurements taken by the **FBG** during the 1993 sampling season ranged from 6.4 to 6.8. Lower pH readings were documented in the hypolimnion (6.3

units) and correspond to elevated carbon dioxide levels (range 7.1 to 21.0 milligrams per liter) near the lakebottom.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals from the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (grey color of dye; pH endpoint of 5.1) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 9 mg per liter (calcium carbonate alkalinity), while the average alkalinity of the lakes studied by the **Freshwater Biology Group** in the **NH LLMP** is approximately 6.3 mg per liter.

When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

The alkalinity levels measured in Silver Lake were low and ranged from 3.5 to 4.3 units. While low, the current alkalinity levels are sufficient to buffer against acid inputs.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans.

The specific conductance of Silver Lake was low, and ranged from 32.0 to 35.0 micro-Siemans at Site 2 Deep, 32.9 to 35.7 micro-Siemans at Site 5 North and 33.7 to 54.0 micro-Siemans at Site 7 North Island.

Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in free carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide**. Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

The dissolved oxygen concentrations remained high at both the 2 Deep and 5 North sampling stations on the August 25 sampling date. However the dissolved oxygen concentrations remained above 5 mg per liter only down to about 8.5 meters at the 7 North Island sampling station. The lower dissolved oxygen concentrations documented in the hypolimnion of the 7 North Island sampling station are associated with the accumulation of organic matter from algal and plant productivity as well as materials flushed into the lake from the lake's watershed (i.e. grass clippings, leaf litter).

Underwater Light *

Underwater light available to photosynthetic organisms is measured with an **underwater photometer** which is much like the light meter of a camera (only waterproofed !). The **photic zone** of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the level where light is reduced, by the absorption and scattering properties of the lake water, to one percent of the surface intensity. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation. Discontinuity (abrupt changes in the slope) of the profiles could be due to metalimnetic layering of algae or other particulates (discussed above). The underwater photometer allows the investigator to measure light at depths below the Secchi Disk depth to supplement the transparency information.

Indicator Bacteria *

Coliform bacteria in water indicate the possibility of fecal contamination. Although they are usually considered harmless to humans, they are much easier to test for than harmful pathogenic enteric bacteria (**Salmonella**, **Shigella** etc.) and viruses that may be present in fecal material. **Total coliform** includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. In 1991, the State of New Hampshire changed the indicator organism of preference to E. Coli which is a specific type of fecal coliform bacteria thought to be a better indicator of human contamination. The new state standard requires Class A bathing waters to be under 88 organisms per 100 milliliters of lakewater.

Ducks and geese are often a common cause of high concentrations of coliform at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch", waterfowl roosting areas offer a greater chance for infestation to occur. Thus while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

Phytoplankton *

The planktonic community includes microbial organisms that represent diverse life forms, containing photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae (the zooplankton are discussed below in a separate section). Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton can be indicative of the trophic status of a lake. Seasonal patterns do occur and must be considered. For example **diatoms**, tend to be most abundant in April-June and October-November, in the surface or epilimnetic layers of New Hampshire lakes. As the summer progresses, the dominant types might shift to **green algae** or **golden algae**. By late season **blue-green bacteria** generally dominate. In nutrient rich lakes, nuisance green algae and/or bluegreen bacteria might dominate continually. After fall mixing diatoms might again be found to bloom.

Phytoplankton samples collected from the surface waters of Silver Lake were low in density (364 organisms per milliliter at Site 5 North and 328 organisms per milliliter at Site 7 North Island) on the August 25 sampling date. The dominant planktonic forms were the bluegreen bacteria, *Aphanocapsa* and *Merrismopedia*, at the 5 North sampling station while the flagellated cryptomonad, *Cryptomonas*, dominated the 7 North Island sampling station. While the algal densities remained low and indicative of unproductive conditions, the types of algae present are commonly associated with more productive waters. The **FBG** will continue to monitor these populations in the future as changing algal composition can be an indication of changing lake productivity.

__Zooplankton__ *

There are three groups of zooplankton that are generally prevalent in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints usually make it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 or 150 microns; 1 million microns make up a meter). Thus, zooplankton analysis is generally restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake.

As discussed above for phytoplankton, zooplankton undergo seasonal population cycles and the results discussed below are most representative of the collection dates and not necessarily of other times during the ice-free season, especially during the early spring and late fall.

Macrozooplankton samples collected from the Silver Lake deep sampling stations were low in density (5.5 animals per liter at Site 2 Deep, 8.0 animals per liter at Site 5 North and 3.5 animals per liter at Site 7 North Island) on the August 25 sampling date (see figure 28; note: the calanoid copepods are not included on the pie charts). All sites were dominated by the calanoid copepod, *Diaptomus*, at the time of **FBG** sampling while the other macrozooplankton taxa present were sparse. The types and densities of macro-zooplankton present are indicative of unproductive waters.

Fish Condition

As with the plankton discussed above, the health of the fish species of a lake will be indicative of the overall water quality. Condition is determined by comparing the length of the fish to its weight. As would be expected, the heavier the fish for its length, the better its condition will be. By also examining a scale collected from the fish under a microscope, the approximate age and growth history can also be determined.

CURRENT CONCERNS

Zebra Mussels

Since first being introduced to North America in 1986, zebra mussels (*Dreissena polymorpha*) have dramatically altered the balance of freshwater systems and fisheries. These small water dwelling animals have also caused millions of dollars in expenses for industrial water users, drinking water facilities, commercial and recreational boaters, farmers, and other groups and organizations in Canada and the Great Lakes region.

The range occupied by these unwelcome visitors has expanded and continues to grow rapidly. In North America, sightings have been recorded as far north as the Saint Lawrence River near Quebec, as far east as the lower portion of the Hudson River, as far south as the Mississippi River near Vicksburg, and as far west as the Arkansas River in Oklahoma.

In 1993, zebra mussel sightings were confirmed in New England (Lake Champlain). The Lake Champlain population has existed for at least a year, if not longer. Thus, New Hampshire residents and boaters are being encouraged to arm themselves with knowledge about the natural history and geographic spread of the mussels. Interstate boaters and anglers, in particular, should become familiar with boating and fishing practices that decrease the likelihood that zebra mussels will be transferred from an infested water body to an uninfested one.

The infestation risk factor for any particular water body is determined mainly by the amount and type of boat traffic it supports and the chemical characteristics and temperature it maintains. While the goal is to prevent the mussels from becoming established in New England waters, zebra mussels have proven to be adaptable creatures able to survive in a growing range of environmental conditions. Cooperative monitoring activities coordinated by the **New Hampshire Lakes Lay Monitoring Program** will help determine if and when zebra mussels become established in this region. If zebra mussels are found, information about control techniques can help those concerned choose the best method to reduce the destructive impacts of the mussels.

What are Zebra Mussels?

Zebra mussels are non-native, freshwater mollusks. Their shells are marked by varying patterns of alternating dark and light bands. They are typically less than two inches long. The veligers (larval form) are free swimming, nearly invisible, and profuse. The adults secrete strong byssal threads by which they attach and reattach themselves to a variety of surfaces. These threads allow them to colonize quickly and reach densities of 100,000 or more mussels per square yard. The mussels have an average lifespan of 3.5 to 5 years.

Zebra mussels originated in the drainage basins of the Black, Caspian, and Aral seas of eastern Europe and have been in northwestern freshwater since the 1700s. Zebra mussels were first found in North America during 1988 in the waters of Lake Saint Clair, which is located between Lake Erie and Lake Huron. It is suspected that they arrived there as free-floating veligers (microscopic larvae) within the ballast waters of a transoceanic ship during 1986.

What do Zebra Mussels do?

In areas they infest, zebra mussels...

* attach themselves to boat hulls, creating drag and fouling moving parts.
* enter boat engine cooling systems, clogging them and causing overheating.
* colonize and clog raw water intake pipes and screens at municipal water facilities, power generating plants, industrial facilities, and shoreline residences.
* produce foul smells and bad tastes in water supplies where they are decomposing.
* litter beaches, making walking hazardous and producing unpleasant odors.
* colonize and contaminate shoals, creating inhospitable fish nesting areas and crowding them.

* compete with zooplankton (an important fish food) for phytoplankton (microscopic algae). This causes a decrease in the amount of phytoplankton and makes the water clearer. However it adversely impacts other members of aquatic food webs, including fish.

* compete with native shellfish

* become prey for diving ducks and some species of fish. However, no predator capable of controlling them has been found.

<u>What can you do?</u>

Take responsibilities for our waters. If you've been boating in fresh water outside of New England within the past 10 days and plan to launch locally, please...

Inspect your boat and trailer for weeds. Remove and discard any you find. Zebra mussels are commonly found on aquatic plants in areas of infestation.

Flush the cooling system, bilge areas and live wells with tap water.

Discard all bait that has contacted waters that might be infested.

Leave your boat out of water to dry for 48 hours. If it is visibly fouled by algae, leave it out until the exterior is completely dry **or...**

Wash down the hull at a car wash. Hot (140 degree F) water kills zebra mussels and veligers and high pressure spray helps remove them. Wash fouling off your boat away from water sources!

Learn more about the zebra mussel threat in order to be forewarned of the situation and prevent costly repairs or destructive responses.

Share information, ideas and monitoring tasks with other members of your lake association, watershed council, marina club, conservation commission, angling group or civic organization.

Report any sightings to the **New Hampshire Lakes Lay Monitoring Program**. Preserve specimens in alcohol if possible, note the location where they were found, and send them in to confirm the identification.

Remember, so far **no** zebra mussel sightings have been substantiated in New Hampshire waterways. Confirm suspect specimens with an authority before alarming others.

How do you recognize one?

Zebra mussels commonly collect in vegetation, on docks or pilings, and along shoreline cobble and rocks.

* Adult zebra mussels are about the size of a dime and have dark and light stripes on their shells.

* Each half of the adult shell has a ridge running lengthwise down it. This creates a flat side where the two shells meet.

* Zebra mussels are the only freshwater mussels that attach to objects with byssal threads.

* A gritty feeling on your boat's hull may indicate that zebra mussel veligers have settled.

Where can you get more information?

To receive more information, request an educational presentation for your next group meeting, become involved in monitoring efforts, or confirm an identification, contact:

Jeff Schloss
Lakes Lay Monitoring Program
109 Pettee Hall
University of New Hampshire
Durham NH 03824-3512
(603) 862-3848

or

Julia Dahlgran
Sea Grant/Cooperative Extension
Kingman Farm
University of New Hampshire
Durham NH 03824-3512
(603) 749-1565

Sleuthing Fish Condition in New Hampshire Lakes

Anglers are an important component of New Hampshire's recreation and tourism industry. The state offers warm water fishing in over 400 lakes for species such as bass, crappie, and sometimes, pickerel. In addition, almost 200 lakes offer the chance to catch the much desired cold water species such as land-locked salmon and lake trout. As the demand to fish our lakes continues to increase, so does the concern about the health of our fishery; in light of the increased fishing and boating pressure on NH lakes, increased development throughout our watersheds, and the planned (ie: Rainbow Trout) and accidental (ie: water milfoil) introduction of non-native species, knowledge of native fish condition is critical.

Enter the **Freshwater Biology Group (FBG)**, the applied aquatic research unity of the University of New Hampshire that along with Cooperative Extension, oversees the **NH Lakes Lay Monitoring Program**. In a cooperative study with NH Fish and Game, Dr. Lin Wu, a post doctorate UNH research scientist, and **FBG** co-directors Dr. James Haney of the department of Zoology and Dr. Alan Baker of the department of Plant Biology, have been assessing growth and condition of several sport and non-sport fish in lakes and ponds throughout the state.

The study uses two techniques to investigate fish health: the first, scale analysis, provides age and yearly growth information. Like trees, fish scales have annual growth rings (annuli) that reflect their growth rates and condition. Utilizing a computerized measurement and analysis system, each fish scale sample provides the information to calculate the current age, as well as to back-calculate yearly growth for each fish to its first year. As the average fish age measured was 5 to 8 years, depending on species, much historical information was gained. The second technique uses a condition index, a function of the length and weight of the fish to indicate the fish's health at the time of collection. Essentially, the more weight a fish has for a given length, the healthier it is. Both techniques allow for the return of fish unharmed after measurements are taken and a few scales are carefully scraped off.

Fish from over 50 NH lakes were obtained from NH Fish and Game, and **FBG** research teams using nets and traps. Samples were also taken at winter fishing derbies and provided by volunteer lay monitors who were outfitted with special fish measurement kits. In two years, scales and measurements were taken from over 6400 fish representing 29 different species.

For their initial analyses, the **FBG** investigators selected 33 lakes representative of the wide range of water quality conditions throughout the state and 11 target fish species. Results from the scale analysis indicate that a high percentage of the population of the different species studied reached maturity. This is good news since a high number of mature individuals indicates that reproduction of the population can generally be maintained. There is some indication of fishing pressure on the more popular sport species in that the less popular species, the yellow perch and white perch, had the highest percentage of older individuals.

Weight-length relationships for all of the fish species indicated that the fish populations are not crowded or stunted in any of the study lakes. The study also calculated a relative weight condition index that allows for comparisons to national and regional standards and the development of an in-state standard. In the majority of study lakes, smallmouth and largemouth bass populations, especially those in the Lakes Region and northern lakes, are in very good condition. On the other hand, lake trout, white perch and yellow perch populations in the majority of lakes had relative weights below the national mean.

Study results will provide managers and researchers with a baseline for further investigations into the changing health of the state's fishery resources, insight into the use of water quality data to predict fish growth, and information helpful to predict the effects of species introduction (stocking and non-native invasions). Efforts of the **FBG** researchers are currently focused on such a situation on Newfound Lake, where Fish and Game is planning to introduce alewife to replace the declining smelt (a major food source for salmonoids) population in hopes of invigorating the trout and salmon fishery there. Lab experiments and field surveys will try to predict potential effects. Further field work will determine the effectiveness of the stocking.

For those Lakes which participated in the UNH Fish Condition Program, specific reports were distributed to the appropriate persons. Further information concerning results of this study can be obtained by contacting:

Dr. Lin Wu / Dr. James Haney
Department of Zoology
Spaulding Life Sciences/UNH
Durham NH 03824
(603) 862-2100

Dr. Alan Baker
Department of Plant Biology
Nesmith Hall/UNH
Durham NH 03824
(603) 862-3845

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REPORT FIGURES

Figure 3. Location of the 1993 deep and tributary sampling stations for Silver Lake, Madison, New Hampshire.

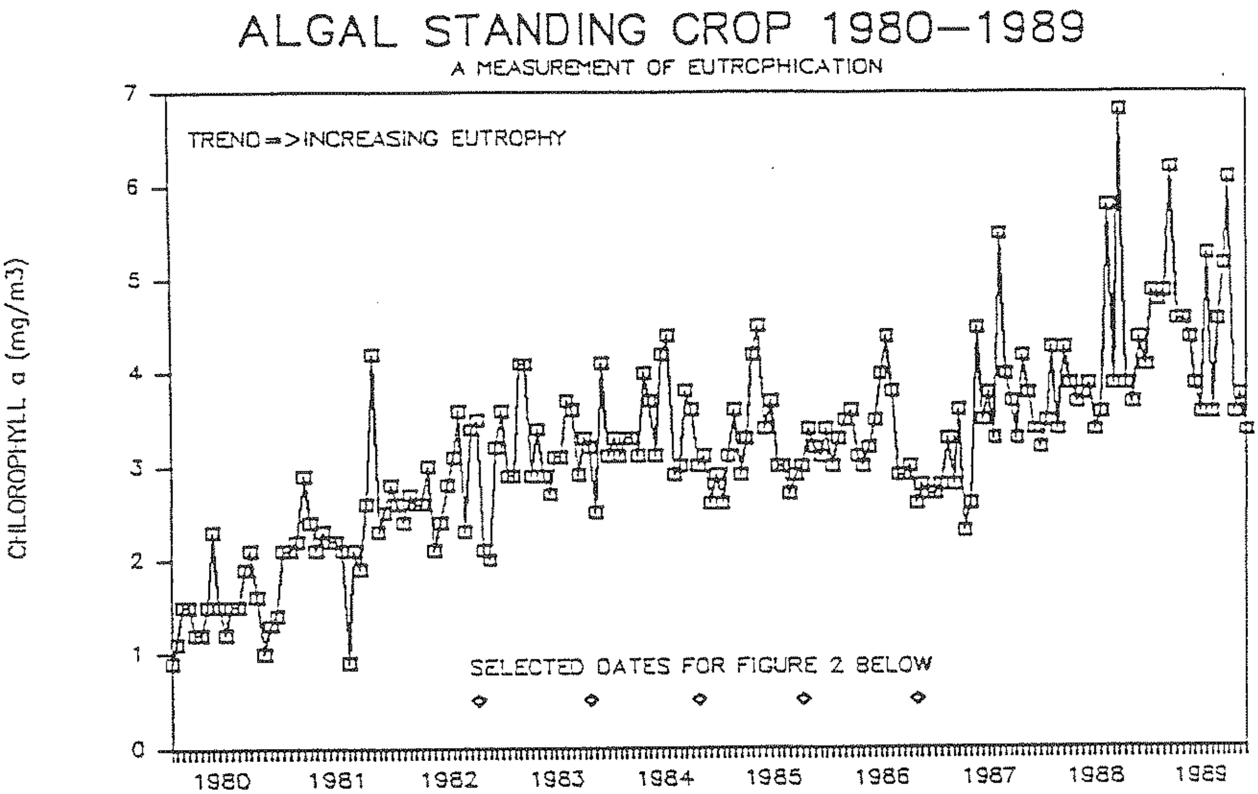


Figure 1. The upper graph depicts weekly chlorophyll concentrations of a model lake measured weekly during ice-free conditions. The long-term trend is that of increased eutrophication (lake has become "greener"). Diamonds below the curve represent late summer (August) dates the data set was subsampled to create Figure 2.

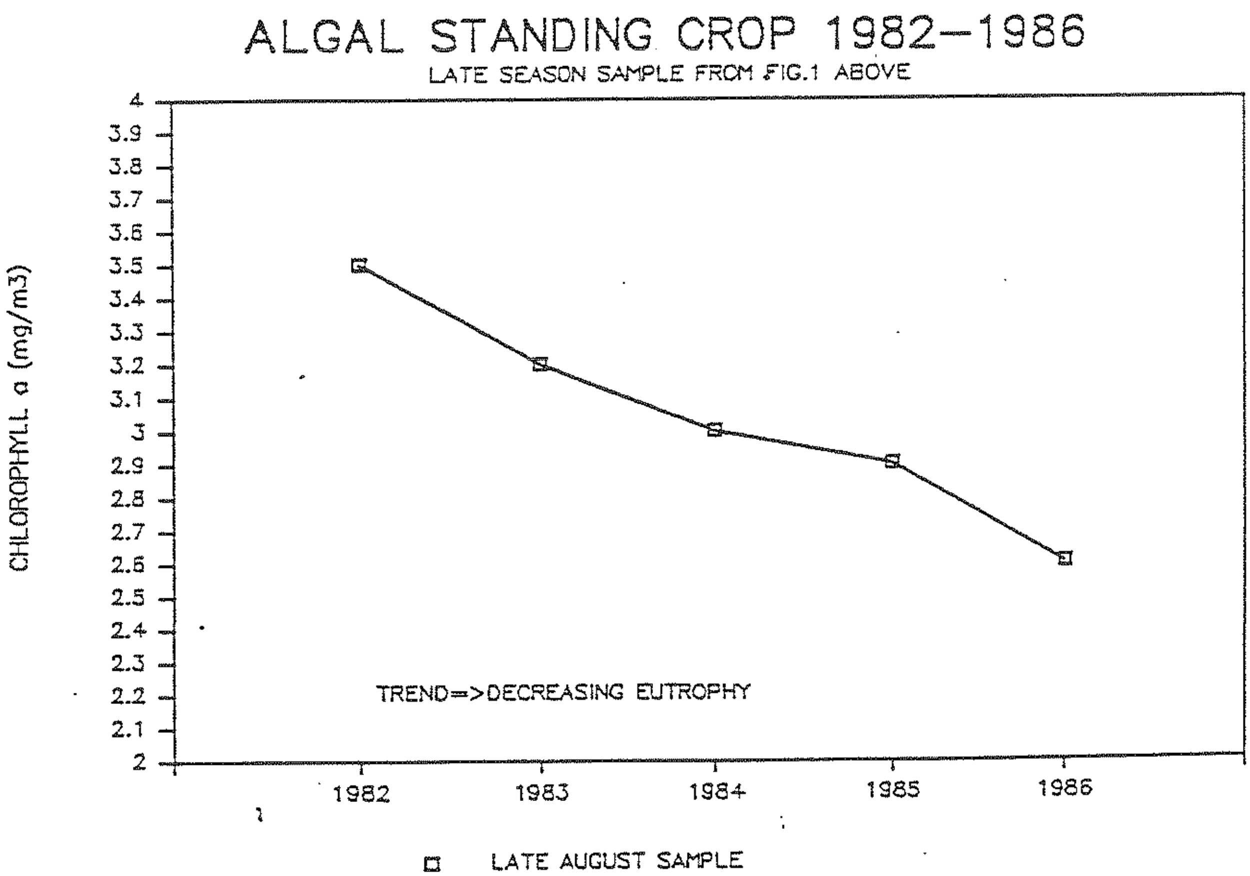
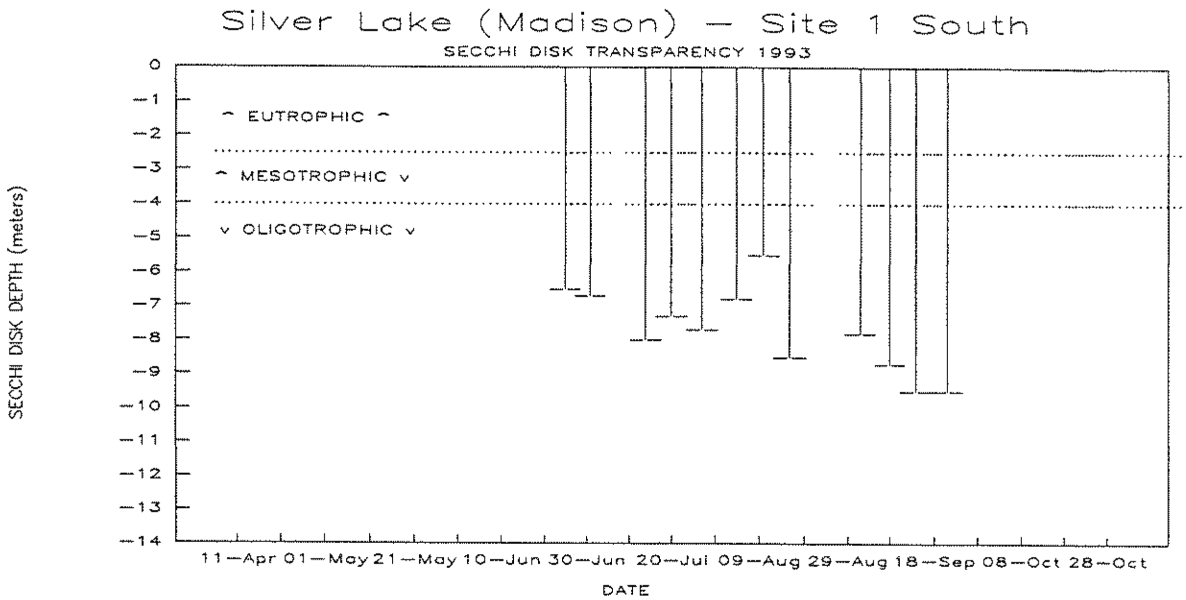


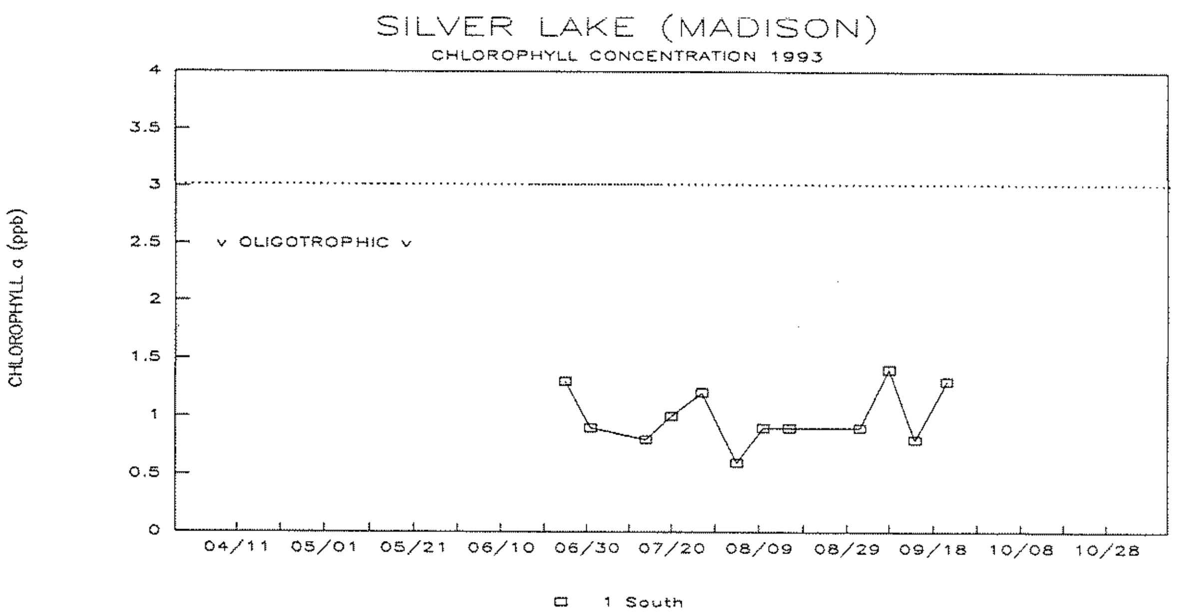
Figure 2. The lower graph depicts late summer chlorophyll data of the model lake in Figure 1. Note how limited sampling over a five year period suggests a much different trend, that of decreasing eutrophy. Thus, limited sampling can mislead the investigator of long-term trends.

Figure 4. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 1 South. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 5. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 1 South. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

Figure 6. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 1 South. Color expressed as platinum-cobalt units (ptu).


Silver Lake (Madison) — Site 1 South
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
11—Apr 01—May 21—May 10—Jun 30—Jun 20—Jul 09—Aug 29—Aug 18—Sep 08—Oct 28—Oct
DATE


SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
1 South

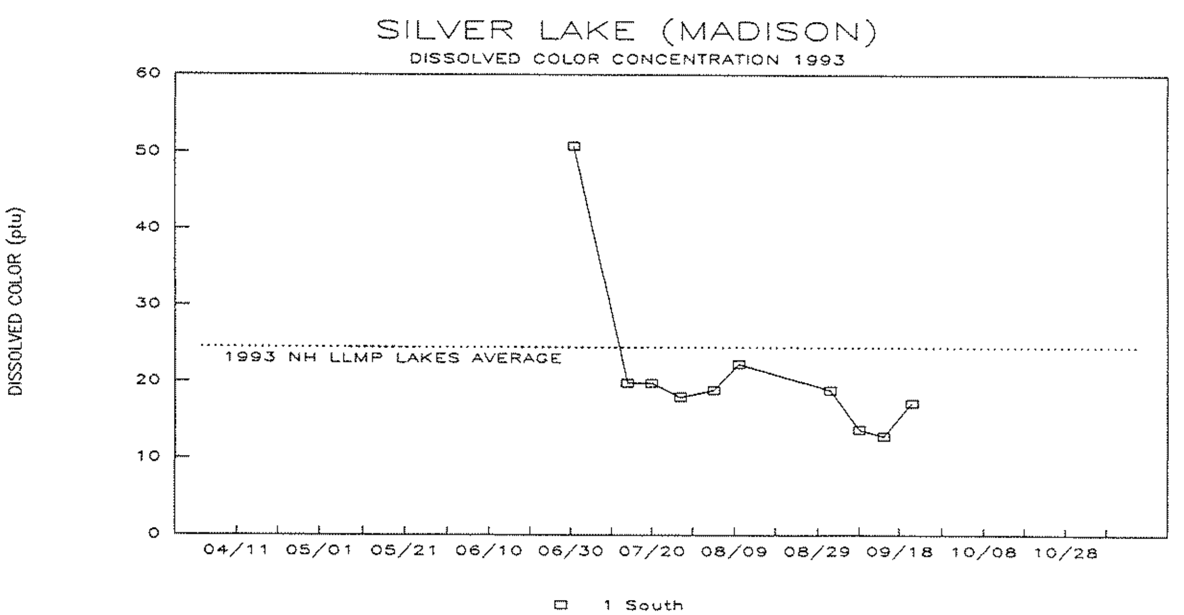
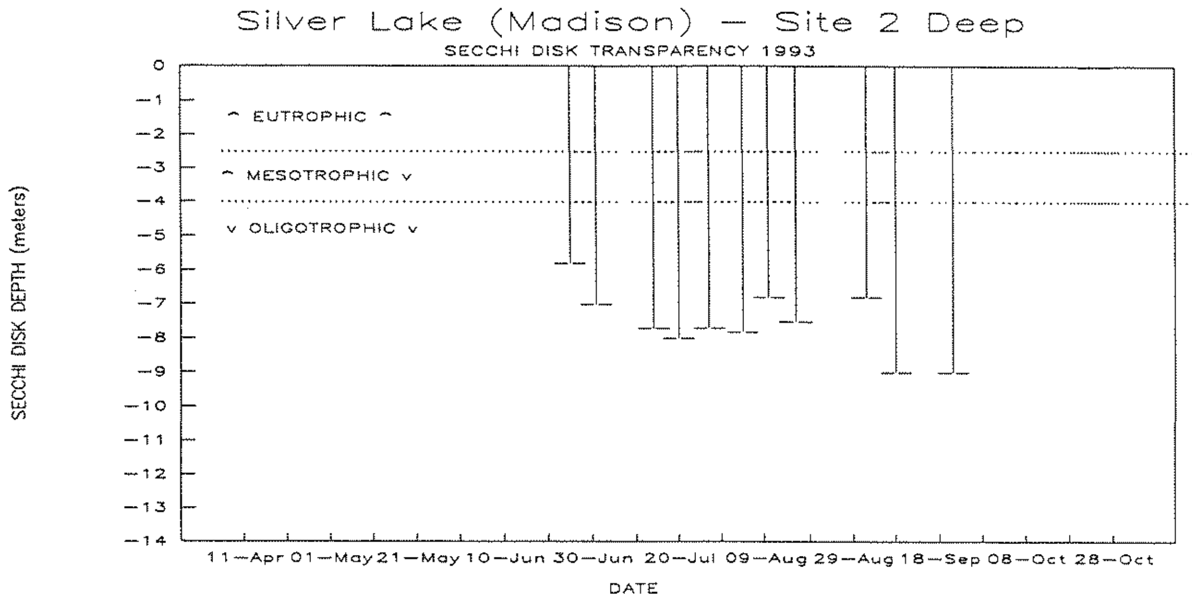
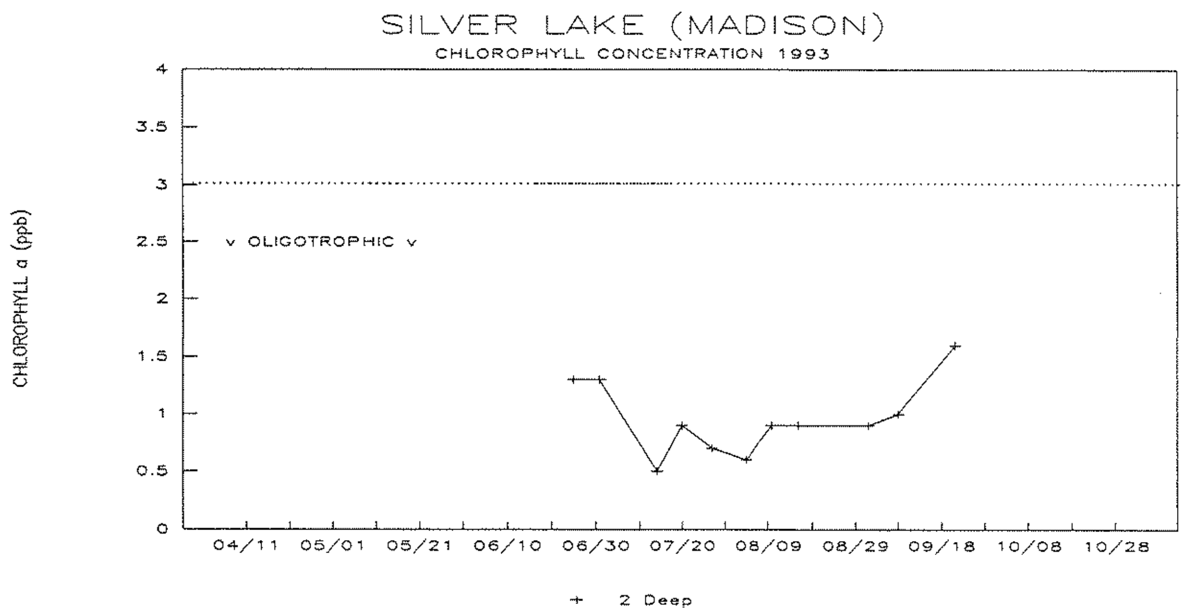

SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (pcu)
1993 NH LLMP LAKES AVERAGE
60
50
40
30
20
10
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
1 South

Figure 7. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 2 Deep. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 8. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 2 Deep. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

Figure 9. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 2 Deep. Color expressed as platinum-cobalt units (ptu).


Silver Lake (Madison) — Site 2 Deep
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
11-Apr 01-May 21-May 10-Jun 30-Jun 20-Jul 09-Aug 29-Aug 18-Sep 08-Oct 28-Oct
DATE


SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
+ 2 Deep

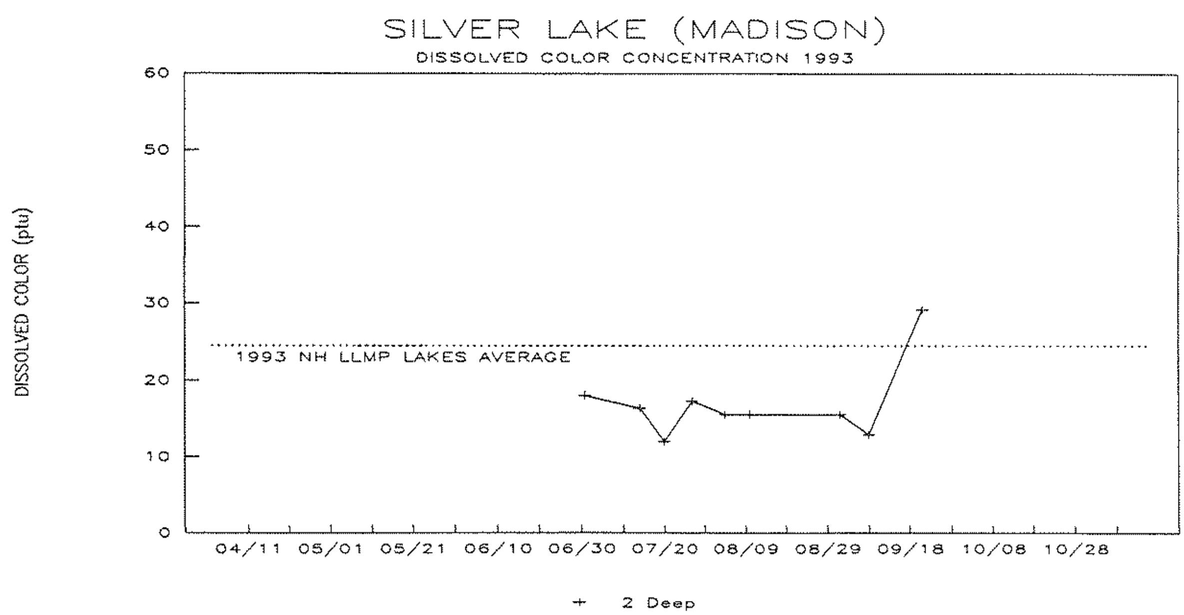
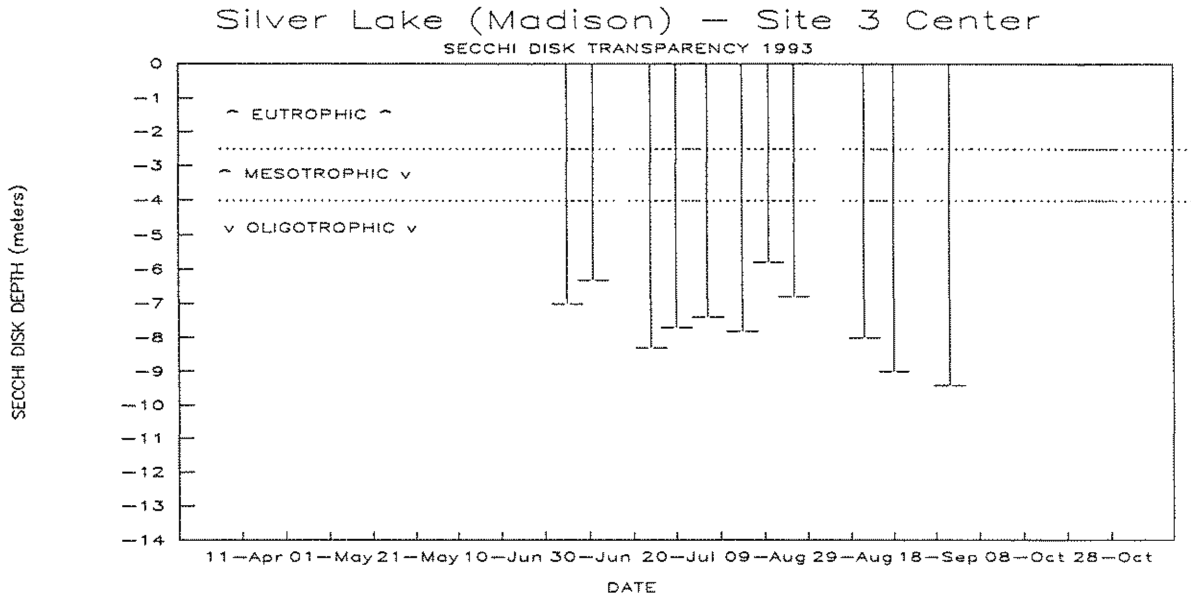
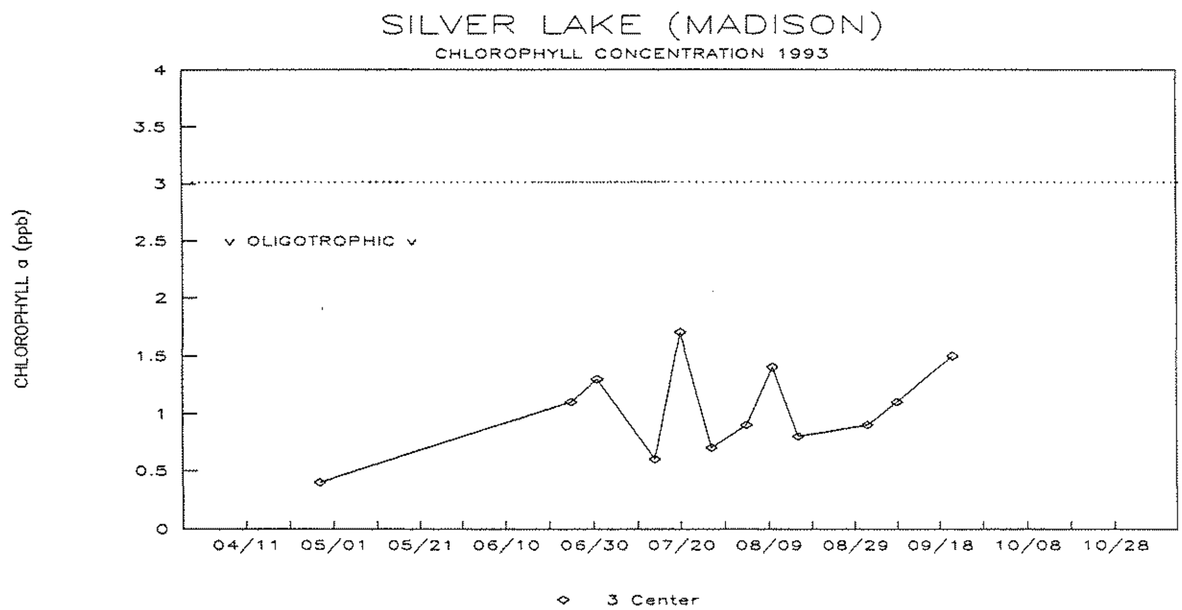

SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
1993 NH LLMP LAKES AVERAGE
60
50
40
30
20
10
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
+ 2 Deep

Figure 10. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 3 Center. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 11. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 3 Center. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

Figure 12. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 3 Center. Color expressed as platinum-cobalt units (ptu).


Silver Lake (Madison) — Site 3 Center
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
11-Apr 01-May 21-May 10-Jun 30-Jun 20-Jul 09-Aug 29-Aug 18-Sep 08-Oct 28-Oct
DATE


SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
3 Center

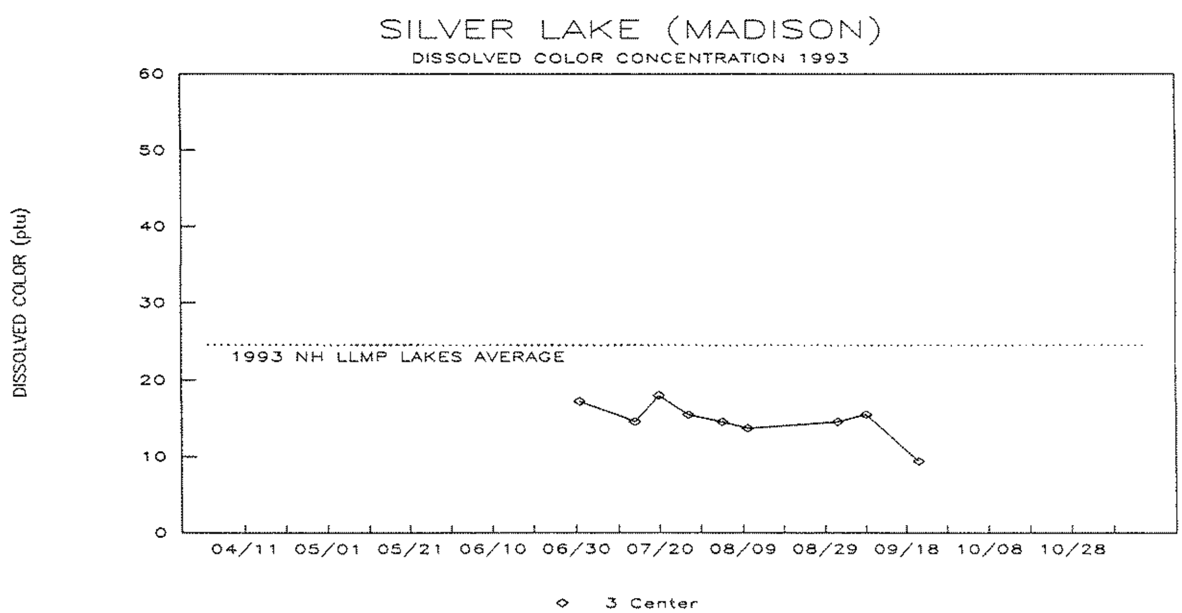
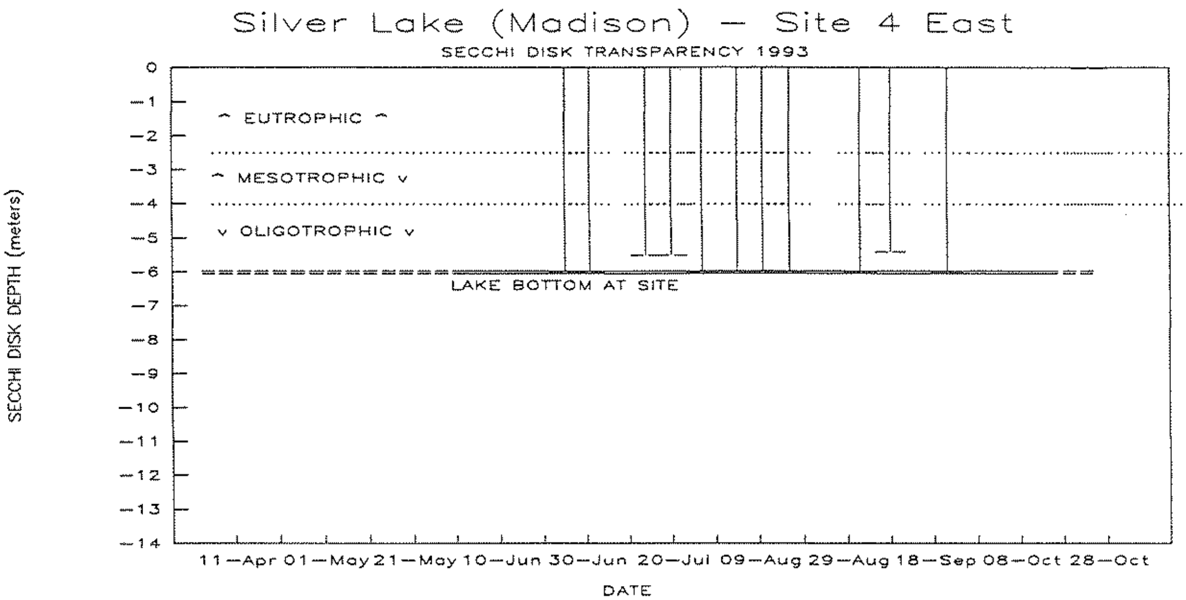
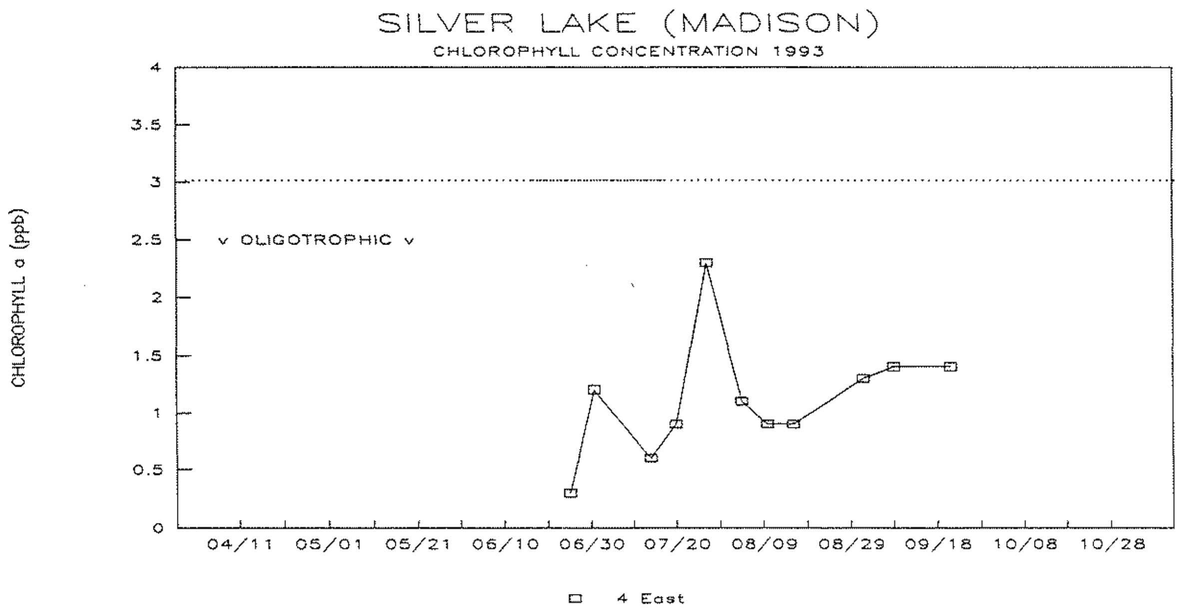

SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
1993 NH LLMP LAKES AVERAGE
60
50
40
30
20
10
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
3 Center

Figure 13. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 4 East. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes while the double solid horizontal line denotes the maximum site depth.

Figure 14. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 4 East. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

Figure 15. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 4 East. Color expressed as platinum-cobalt units (ptu).


Silver Lake (Madison) — Site 4 East
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
DATE
11—Apr 01—May 21—May 10—Jun 30—Jun 20—Jul 09—Aug 29—Aug 18—Sep 08—Oct 28—Oct


SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
4 East

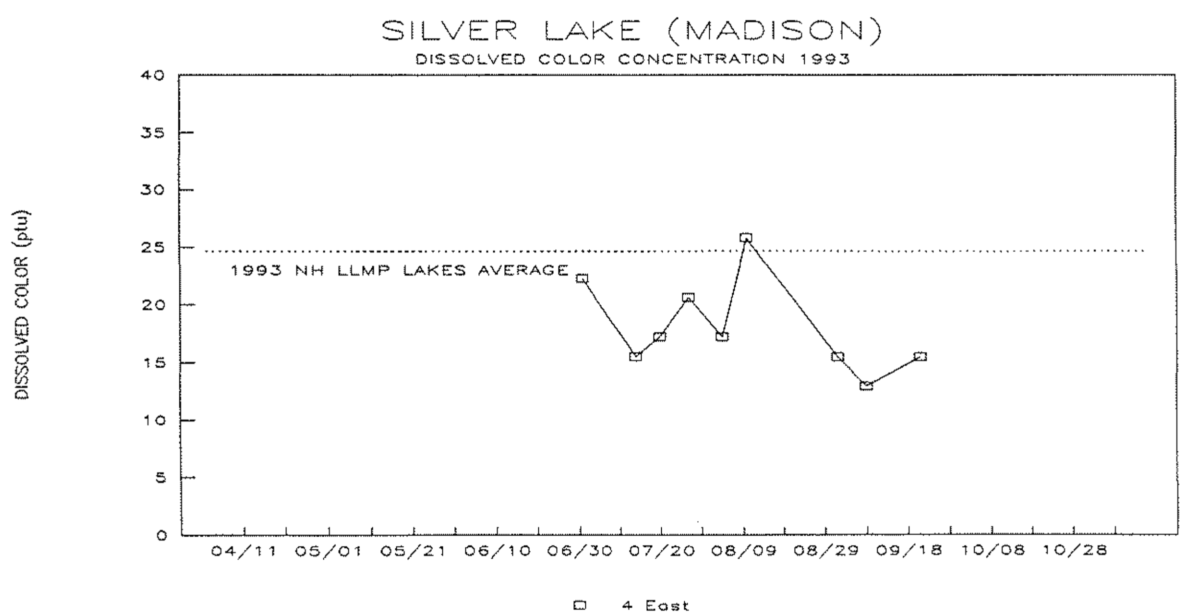
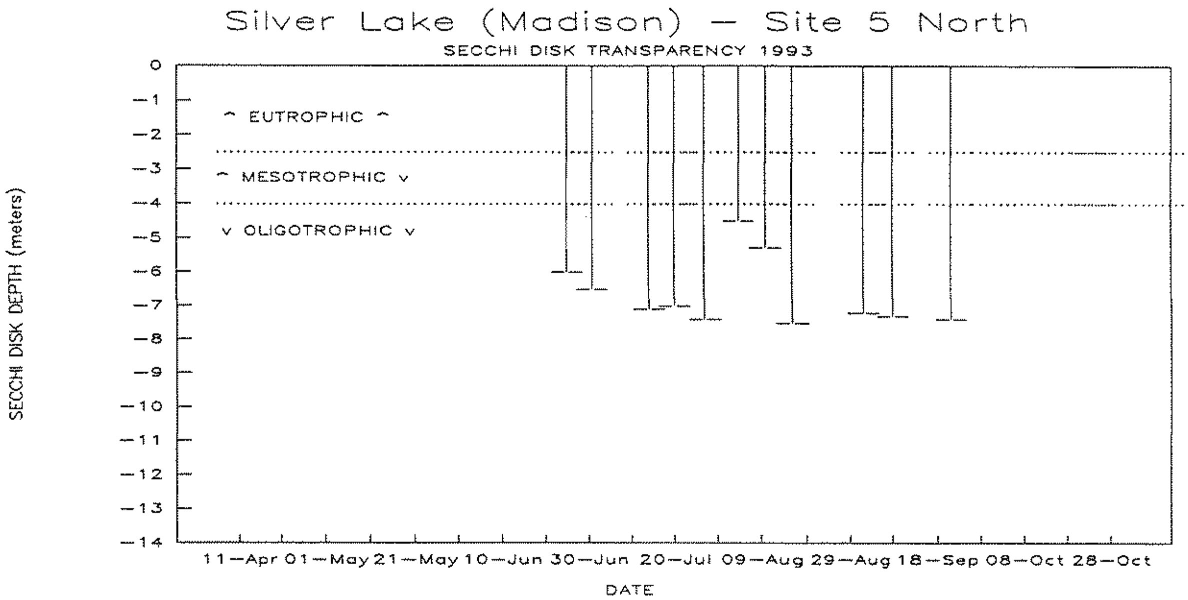

SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
1993 NH LLMP LAKES AVERAGE
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
4 East

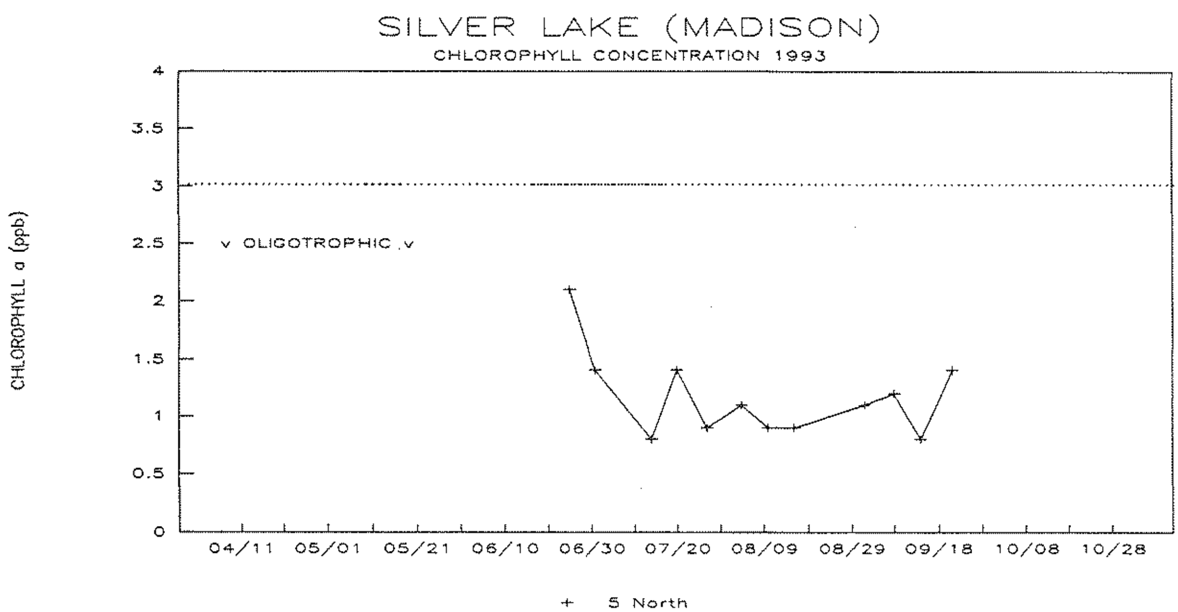
Figure 16. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 5 North. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 17. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 5 North. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

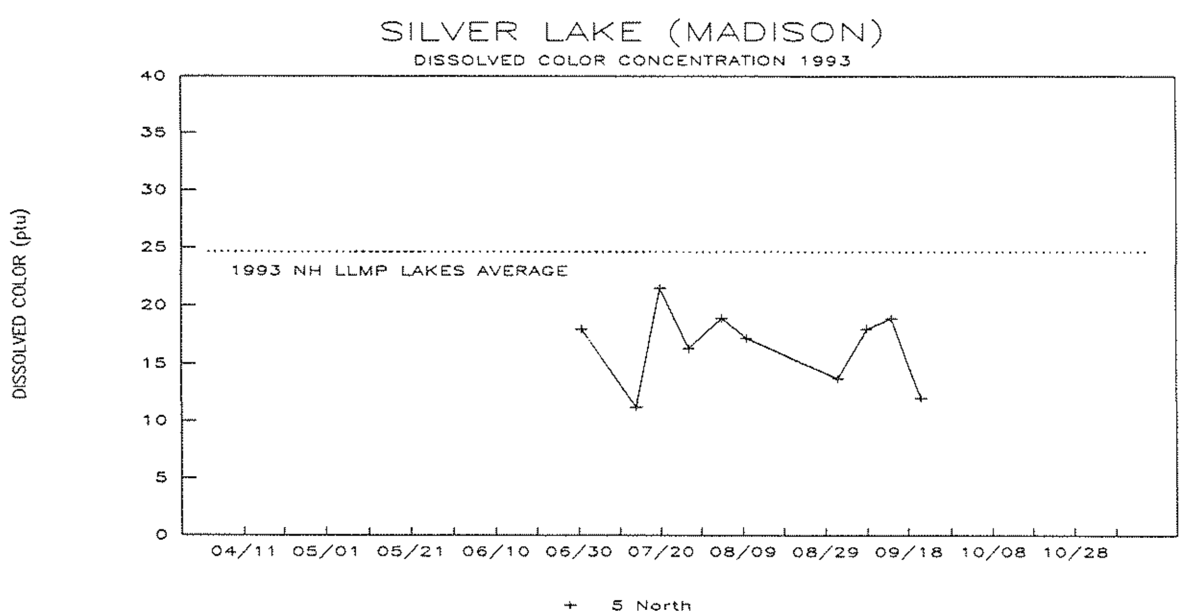
Figure 18. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 5 North. Color expressed as platinum-cobalt units (ptu).



Silver Lake (Madison) — Site 5 North
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
11-Apr 01-May 21-May 10-Jun 30-Jun 20-Jul 09-Aug 29-Aug 18-Sep 08-Oct 28-Oct
DATE



SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
4
3.5
3
2.5
2
1.5
1
0.5
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
+ 5 North

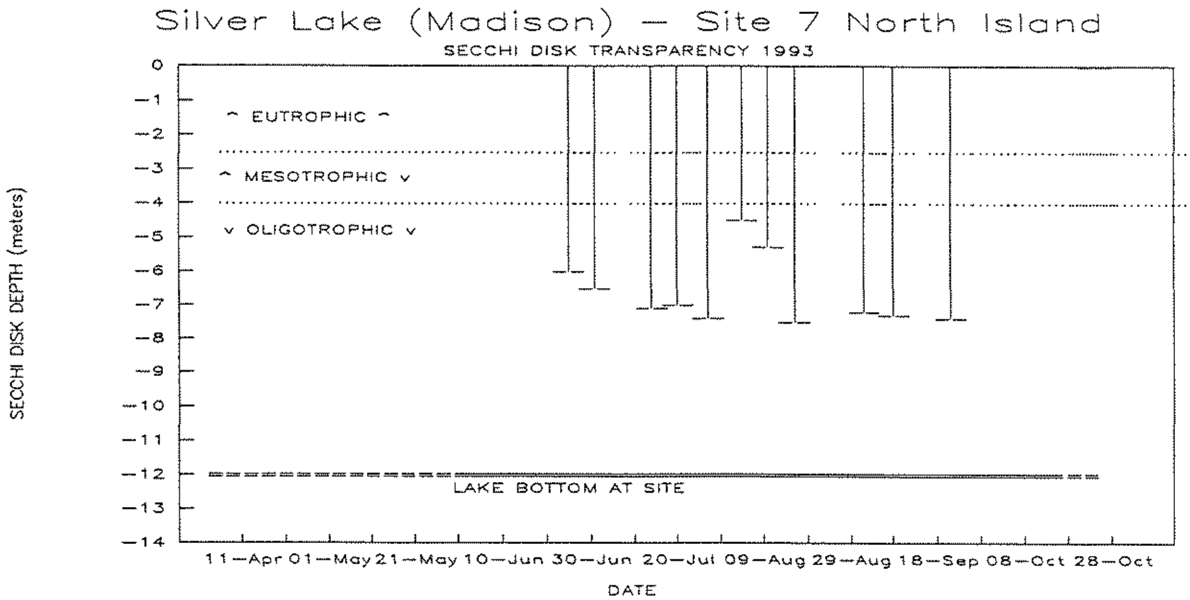


SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
1993 NH LLMP LAKES AVERAGE
40
35
30
25
20
15
10
5
0
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
+ 5 North

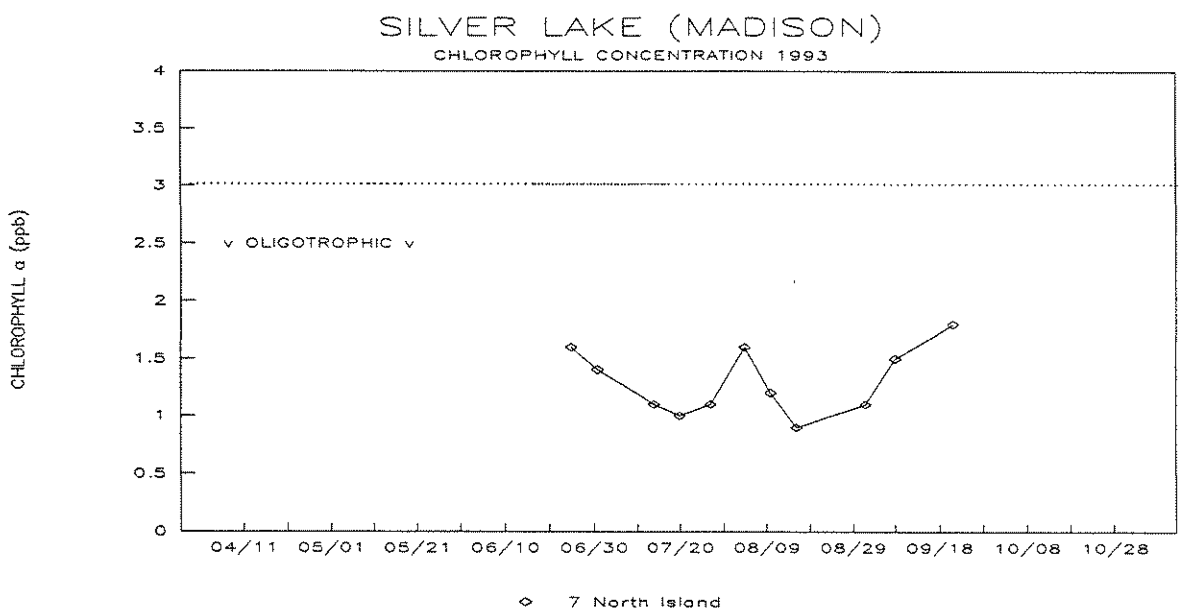
Figure 19. Silver Lake, 1993. Seasonal trends for Secchi Disk Depth (water transparency) of lay monitor Site 7 North Island. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 20. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Site 7 North Island. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

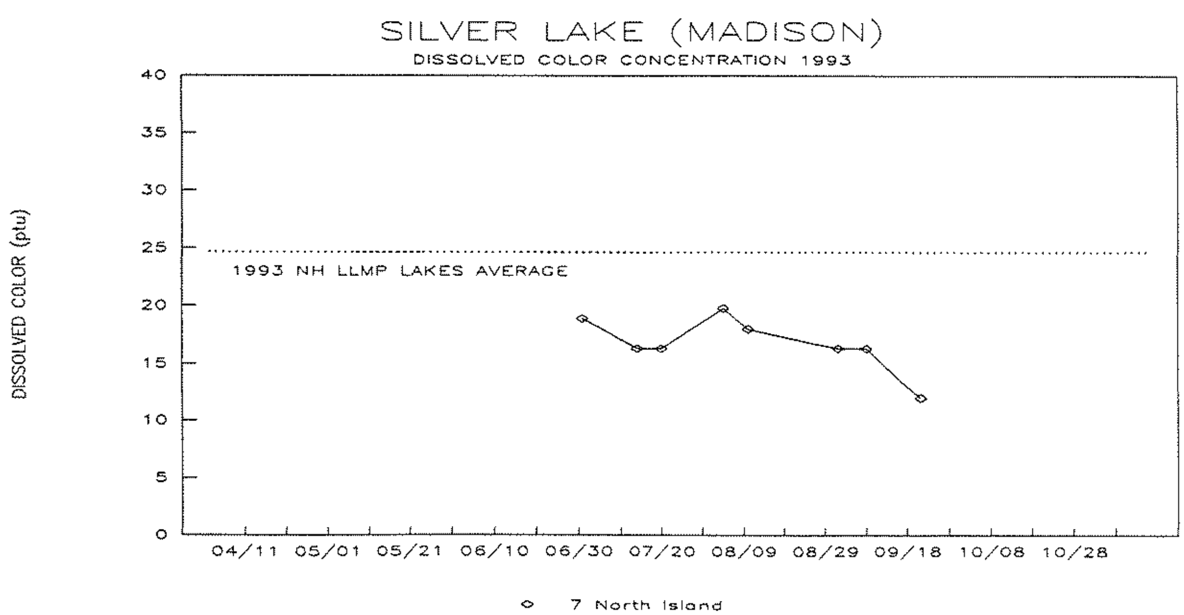
Figure 21. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Site 7 North Island. Color expressed as platinum-cobalt units (ptu).



Silver Lake (Madison) — Site 7 North Island
SECCHI DISK TRANSPARENCY 1993
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
11—Apr 01—May 21—May 10—Jun 30—Jun 20—Jul 09—Aug 29—Aug 18—Sep 08—Oct 28—Oct
DATE



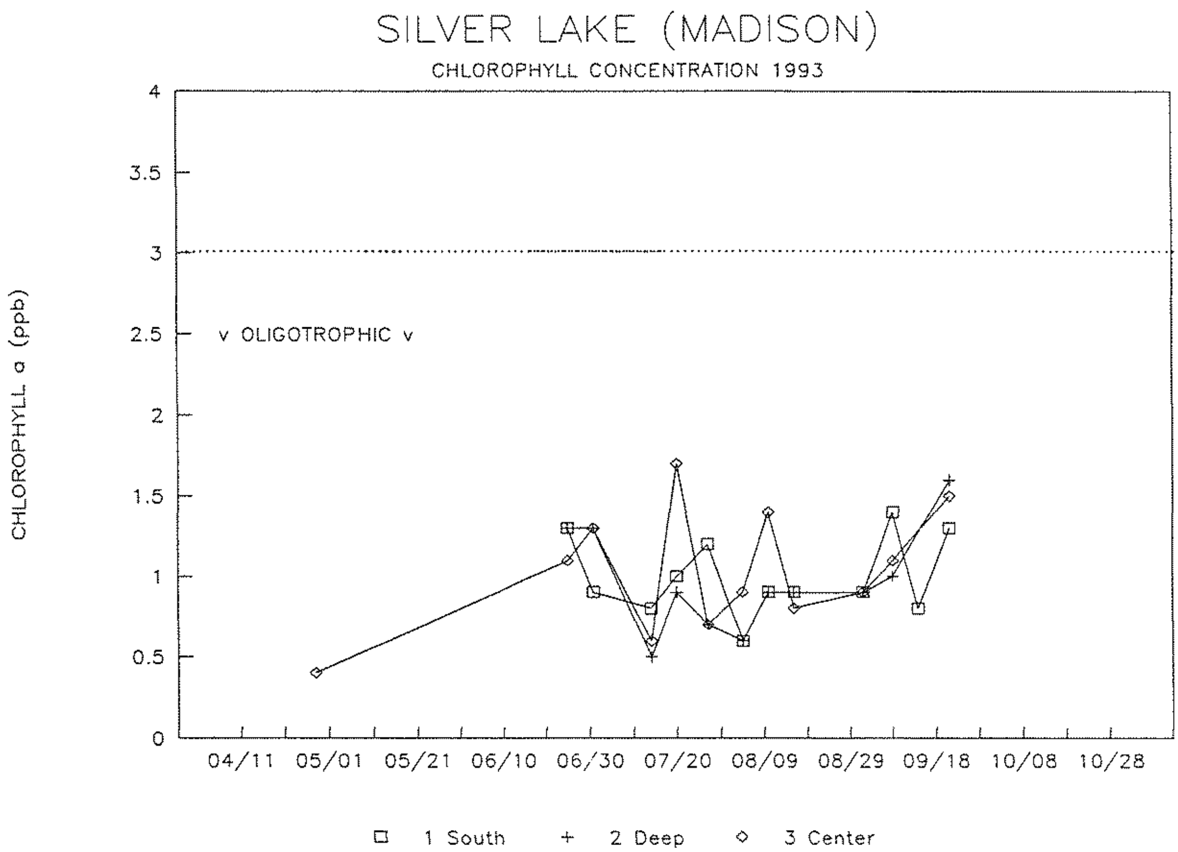
SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
v OLIGOTROPHIC v
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
7 North Island



SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
1993 NH LLMP LAKES AVERAGE
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
7 North Island

Figure 22. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Sites 1 South (squares), 2 Deep (crosses) and 3 Center (diamonds). Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line on the plot borders the ranges common to oligotrophic and mesotrophic lakes.

Figure 23. Silver Lake, 1993. Seasonal trends for chlorophyll *a* concentration of lay monitor Sites 4 East (squares), 5 North (crosses) and 7 North Island (diamonds). Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*. The dotted horizontal line borders the ranges common to oligotrophic and mesotrophic lakes.


SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
4
3.5
3
2.5
2
1.5
1
0.5
0
v OLIGOTROPHIC v
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
1 South
2 Deep
3 Center

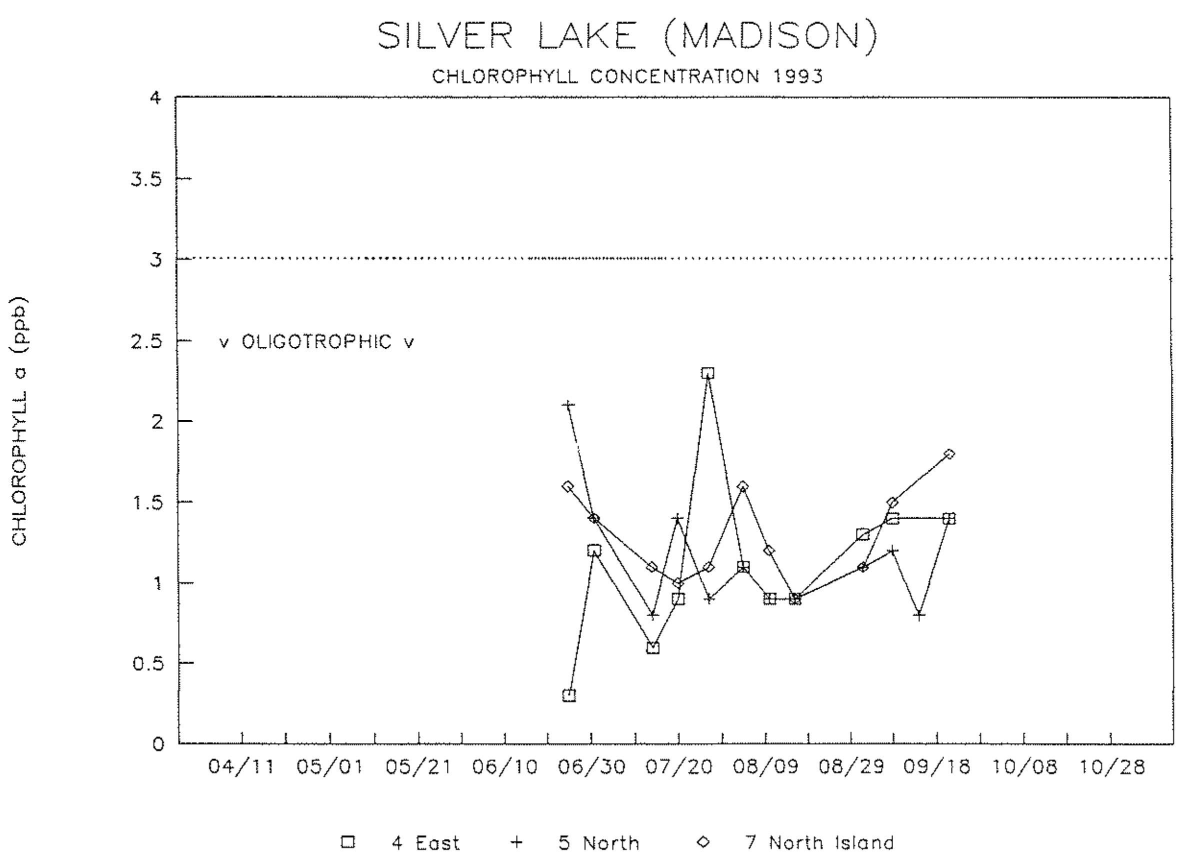
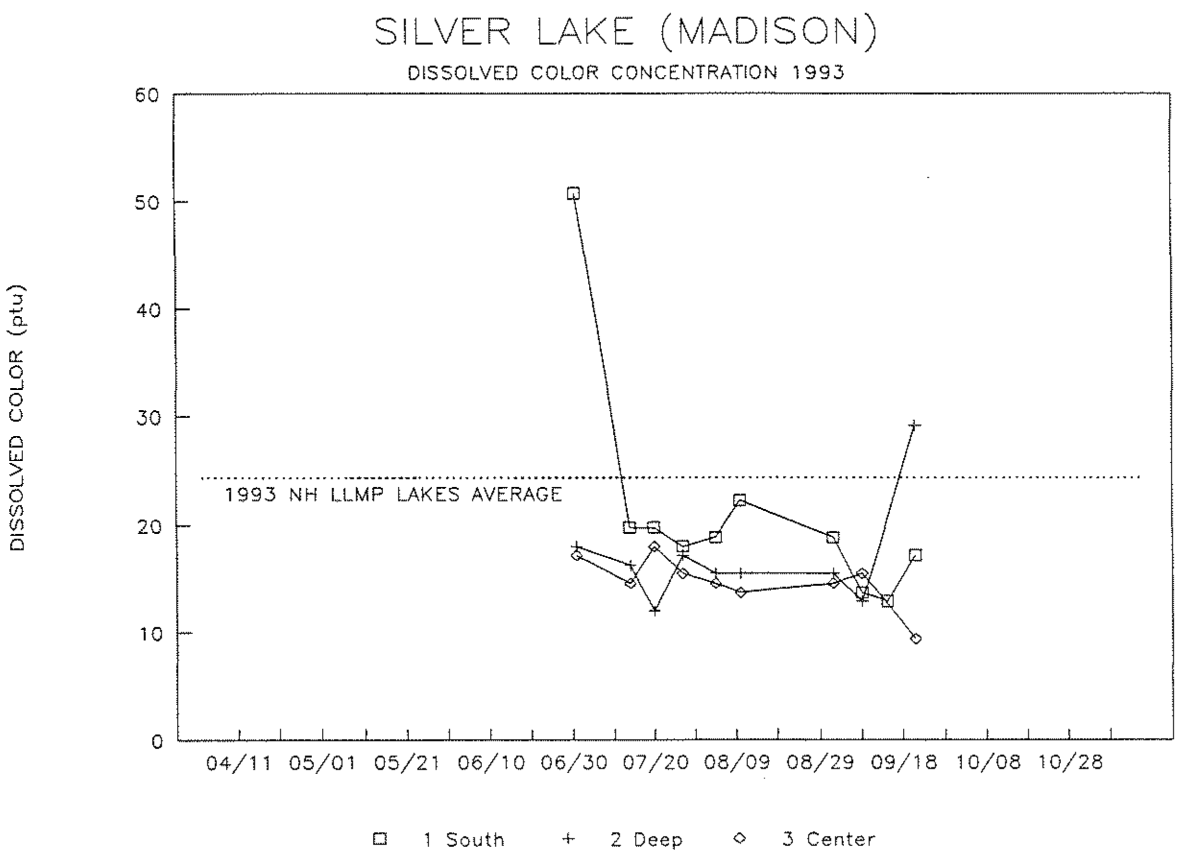
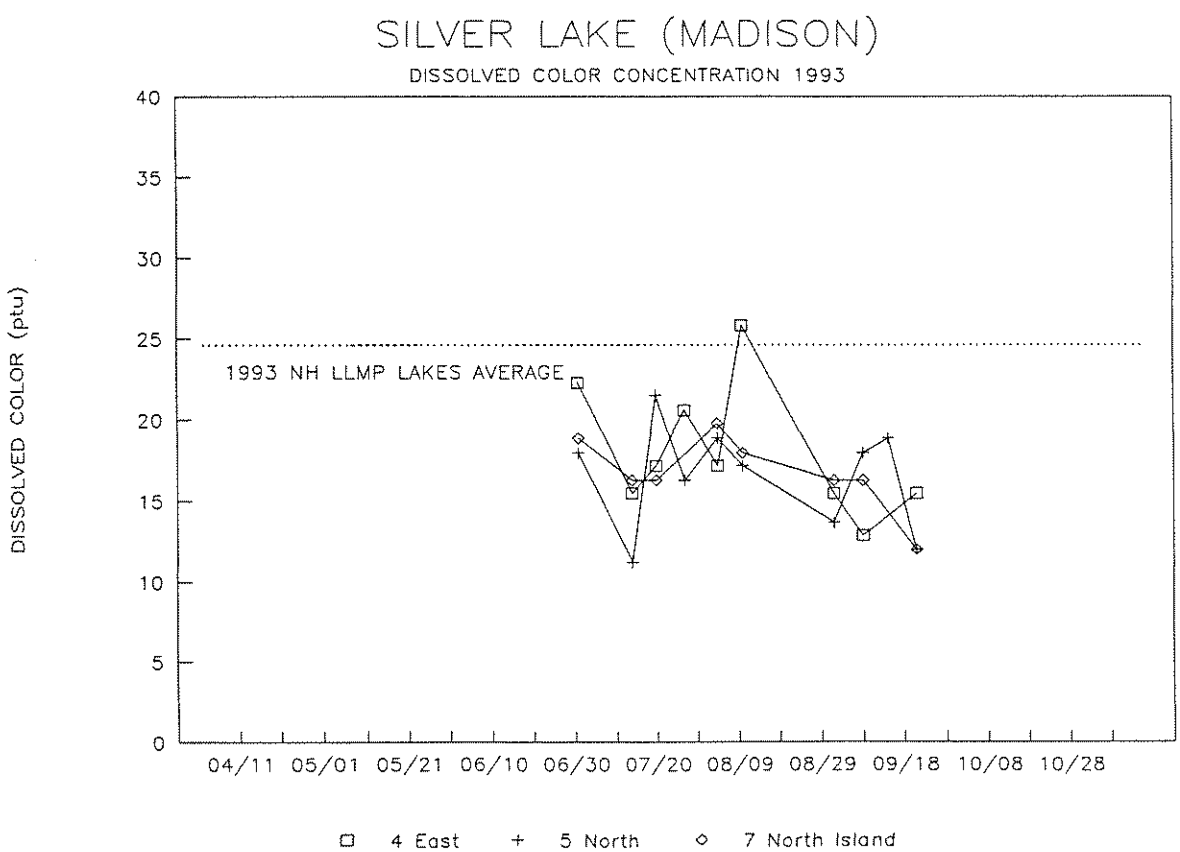

SILVER LAKE (MADISON)
CHLOROPHYLL CONCENTRATION 1993
CHLOROPHYLL a (ppb)
4
3.5
3
2.5
2
1.5
1
0.5
0
v OLIGOTROPHIC v
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
4 East
5 North
7 North Island

Figure 24. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Sites 1 South (squares), 2 Deep (crosses) and 3 Center (diamonds). Color expressed as platinum-cobalt units (ptu).

Figure 25. Silver Lake, 1993. Seasonal trends for dissolved color concentration of lay monitor Sites 4 East (squares), 5 North (crosses) and 7 North Island (diamonds). Color expressed as platinum-cobalt units (ptu).



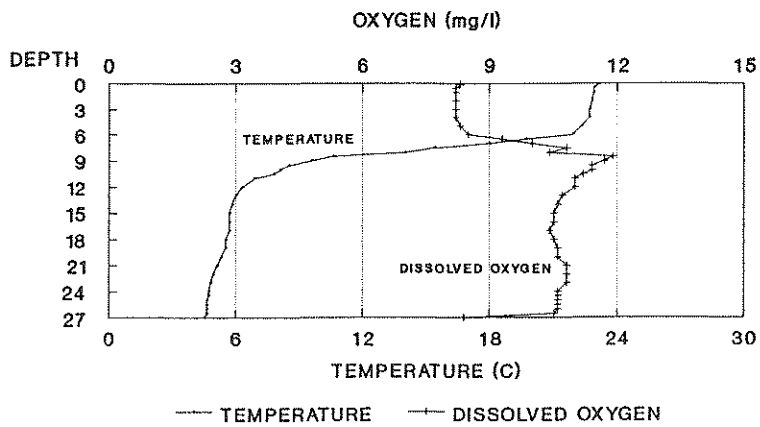
SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
60
50
40
30
20
10
0
1993 NH LLMP LAKES AVERAGE
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
1 South
2 Deep
3 Center



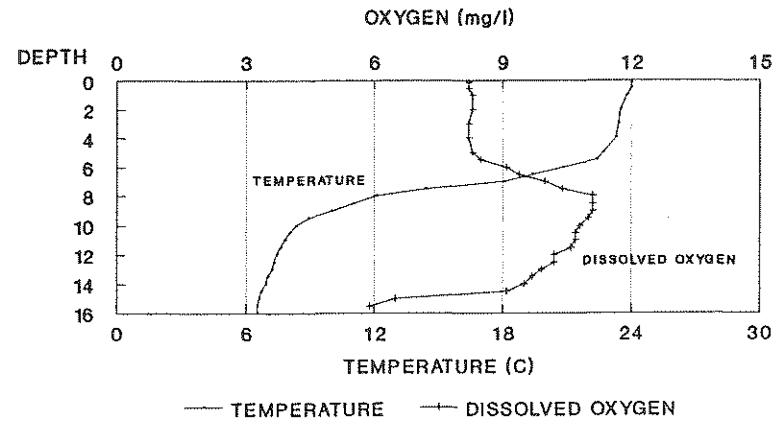
SILVER LAKE (MADISON)
DISSOLVED COLOR CONCENTRATION 1993
DISSOLVED COLOR (ptu)
40
35
30
25
20
15
10
5
0
1993 NH LLMP LAKES AVERAGE
04/11 05/01 05/21 06/10 06/30 07/20 08/09 08/29 09/18 10/08 10/28
4 East
5 North
7 North Island

Figure 26. Profiles of temperature (TEMPERATURE) and dissolved oxygen (DISSOLVED OXYGEN) collected in Silver Lakes. The site name and collection date are as indicated above the respective graphs. Dissolved oxygen and temperature readings were measured at one-half meter intervals.

TEMPERATURE/DISSOLVED OXYGEN PROFILE
SILVER LAKE (MADISON) - SITE 2 DEEP
AUGUST 25, 1993



TEMPERATURE/DISSOLVED OXYGEN PROFILE
SILVER LAKE (MADISON) - SITE 5 NORTH
AUGUST 25, 1993



TEMPERATURE/DISSOLVED OXYGEN PROFILE
SILVER LAKE (MADISON) - SITE 7 NORTH ISL
AUGUST 25, 1993

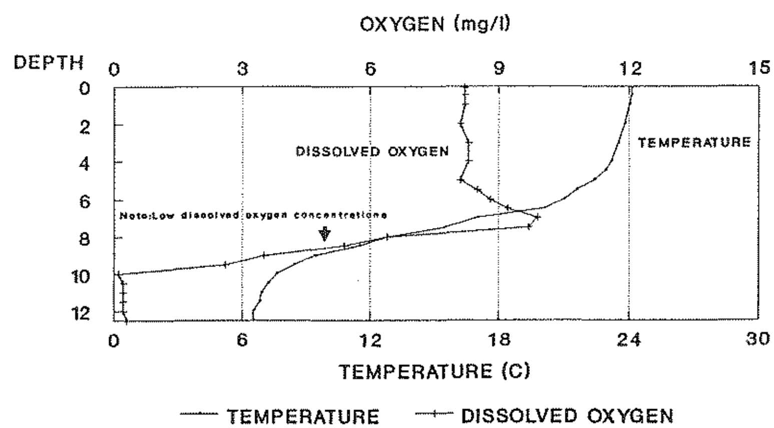
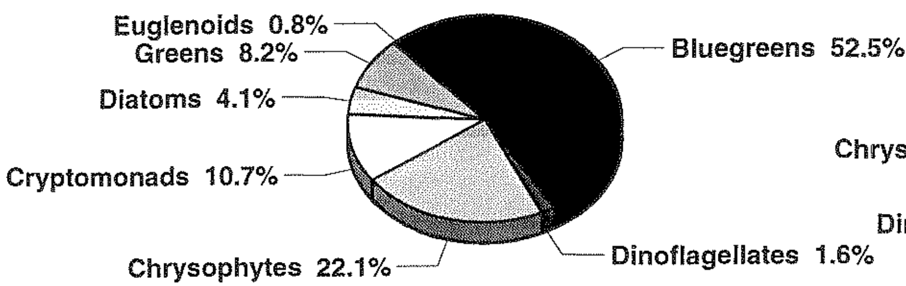


Figure 27. Pie diagrams of Phytoplankton Abundance by algal class in Silver Lake; (A) Site 5 North and (B) Site 7 North Island. The phytoplankton samples were collected on August 25, 1993 while the sampling depth is listed above the respective graphs. The phytoplankton abundance is presented as percent abundance by algal class.

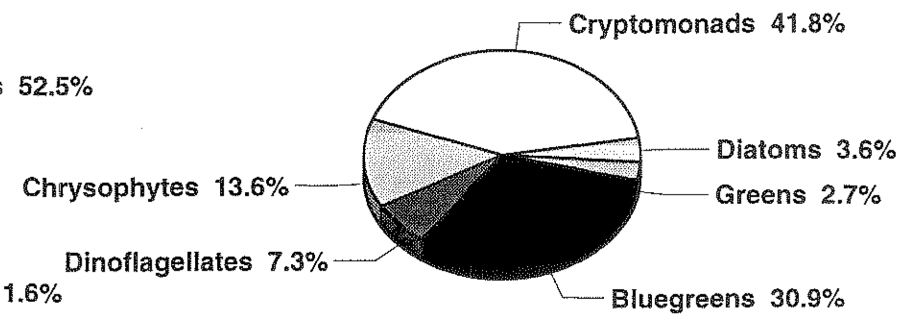
SILVER LAKE (MADISON)

AUGUST 25, 1993

Site 5 North
Depth of Tow: 0 - 5.5m



Site 7 North Island
Depth of Tow: 0 - 4.5m



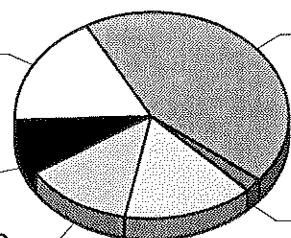
Phytoplankton densities are presented as % abundance by algal class.

Figure 28. Pie diagrams of Macro-Zooplankton abundance for Silver Lake; (A) Site 2 Deep, (B) Site 5 North and (C) Site 7 North Island collected on August 25, 1993. The site name and the depth of macro-zooplankton tow are listed above the respective graphs. The macro-zooplankton densities are presented as number of animals per liter..

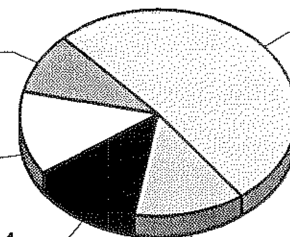
SILVER LAKE (MADISON)

AUGUST 25, 1993

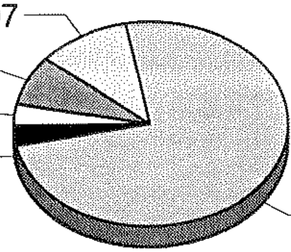
SITE 2 DEEP
DEPTH OF TOW: 0 - 24.0m



SITE 5 NORTH
DEPTH OF TOW: 0 - 15.0m



SITE 7 NORTH ISLAND
DEPTH OF TOW: 0 - 11.5m

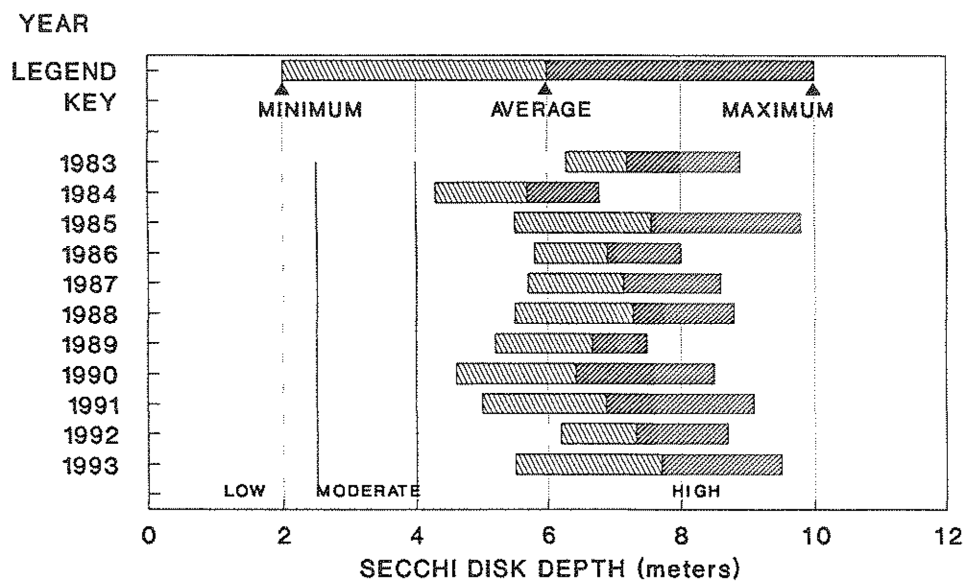


Macrozooplankton densities are presented as # animals per liter.

Figure 29. Silver Lake, Site 1 South. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

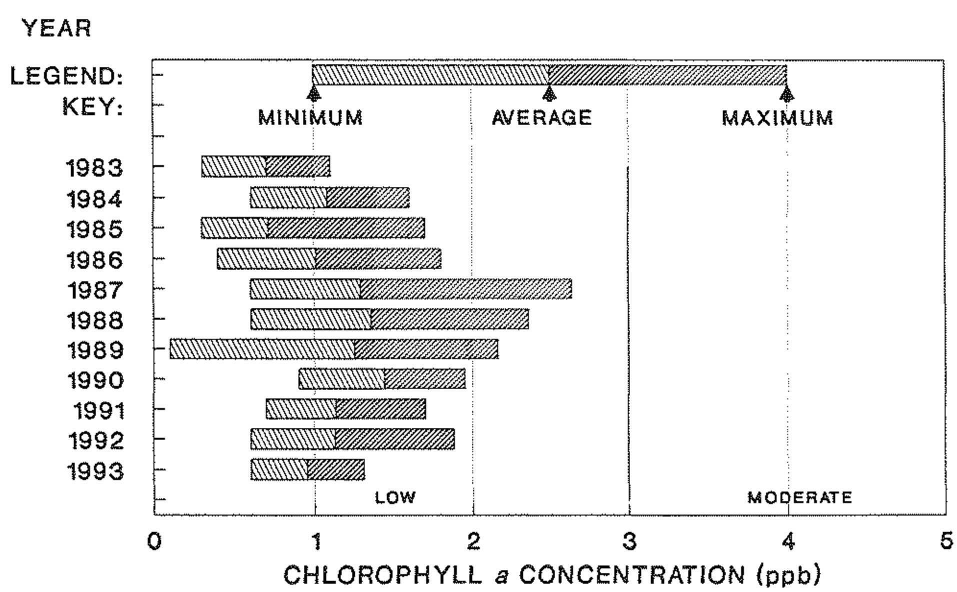
Figure 30. Silver Lake, Site 1 South. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 1 SOUTH
YEARLY COMPARISONS (1983-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 1 SOUTH
YEARLY COMPARISONS (1983-1993)

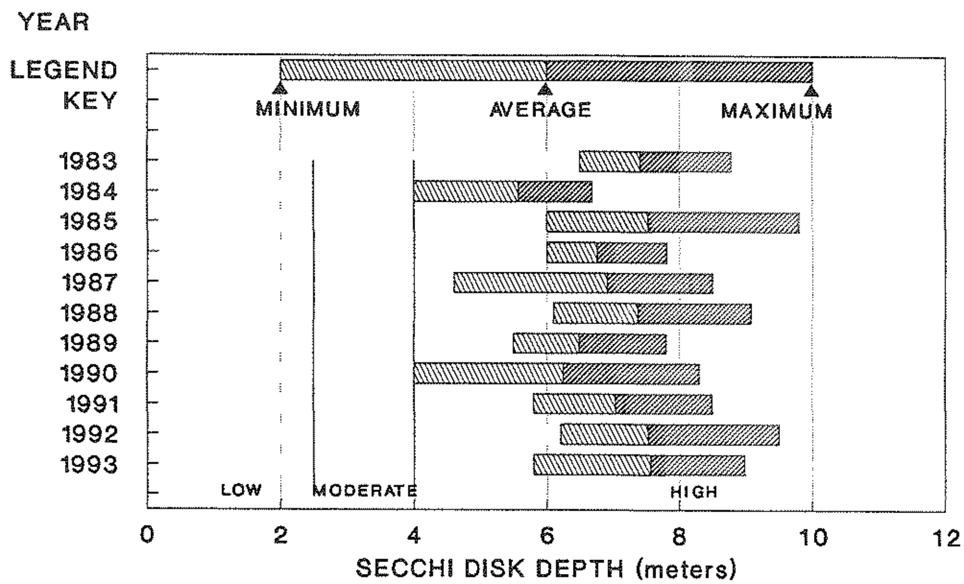


The higher value = more algal growth

Figure 31. Silver Lake, Site 2 Deep. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

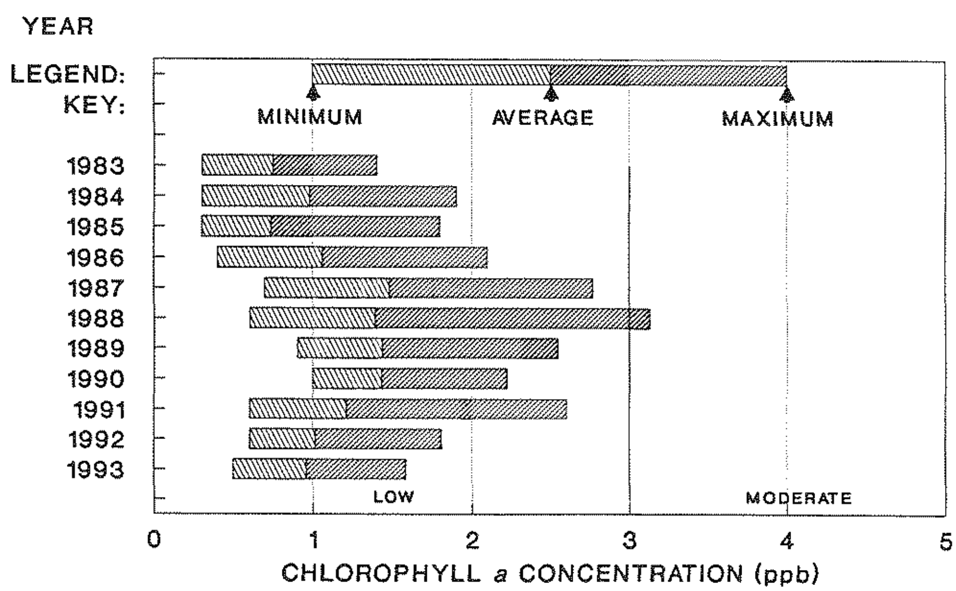
Figure 32. Silver Lake, Site 2 Deep. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 2 DEEP
YEARLY COMPARISONS (1983-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 2 DEEP
YEARLY COMPARISONS (1983-1993)

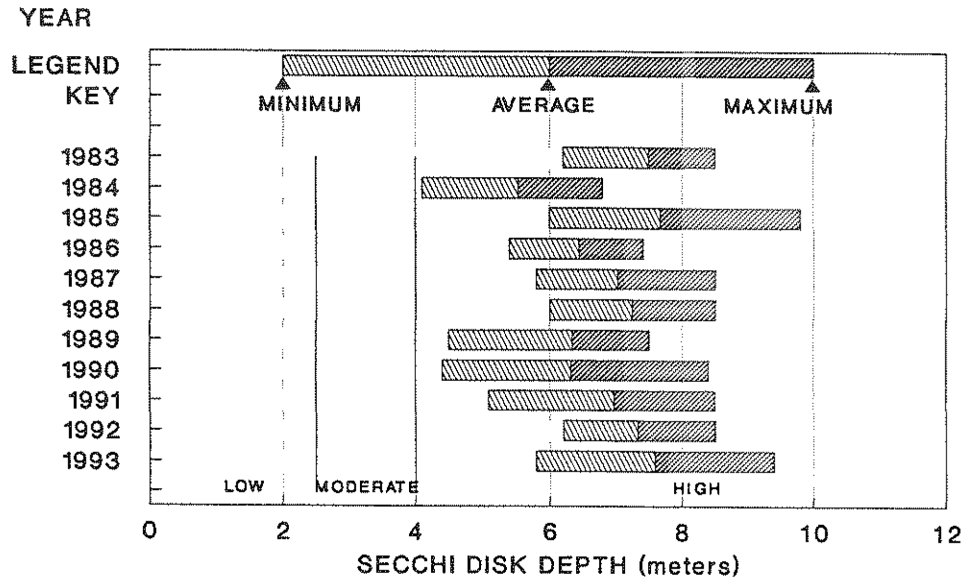


The higher value = more algal growth

Figure 33. Silver Lake, Site 3 Center. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

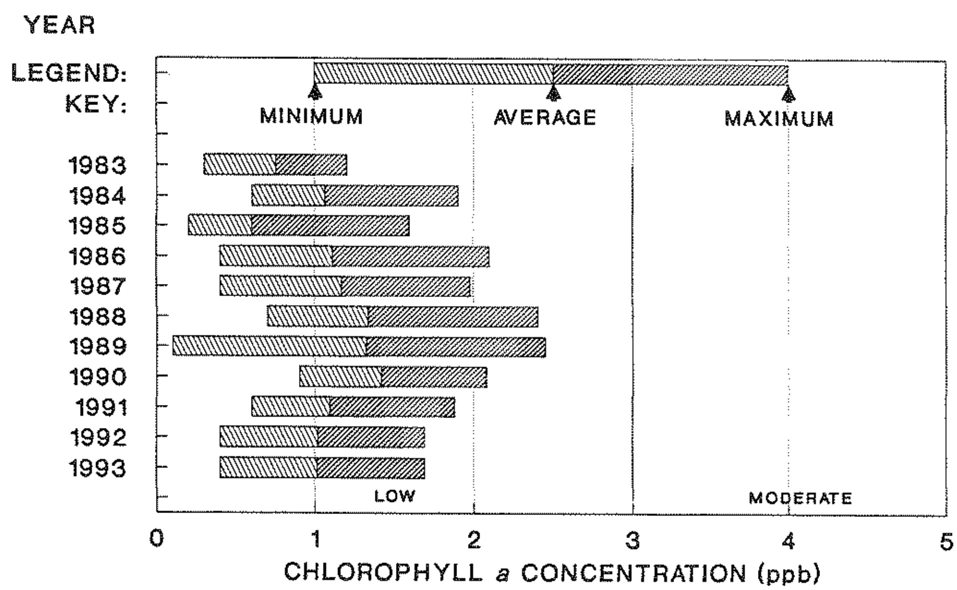
Figure 34. Silver Lake, Site 3 Center. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 3 CENTER
YEARLY COMPARISONS (1983-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 3 CENTER
YEARLY COMPARISONS (1983-1993)

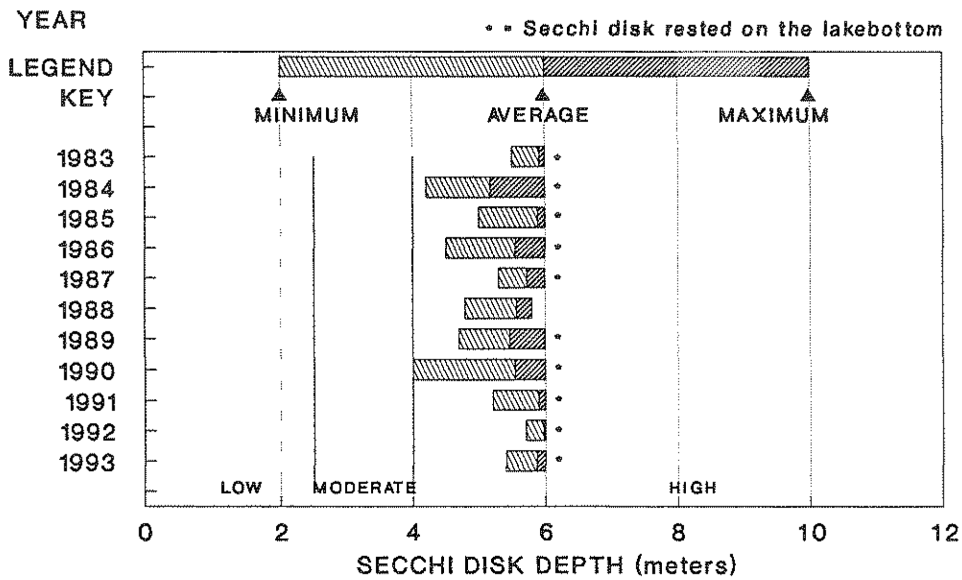


The higher value = more algal growth

Figure 35. Silver Lake, Site 4 East. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

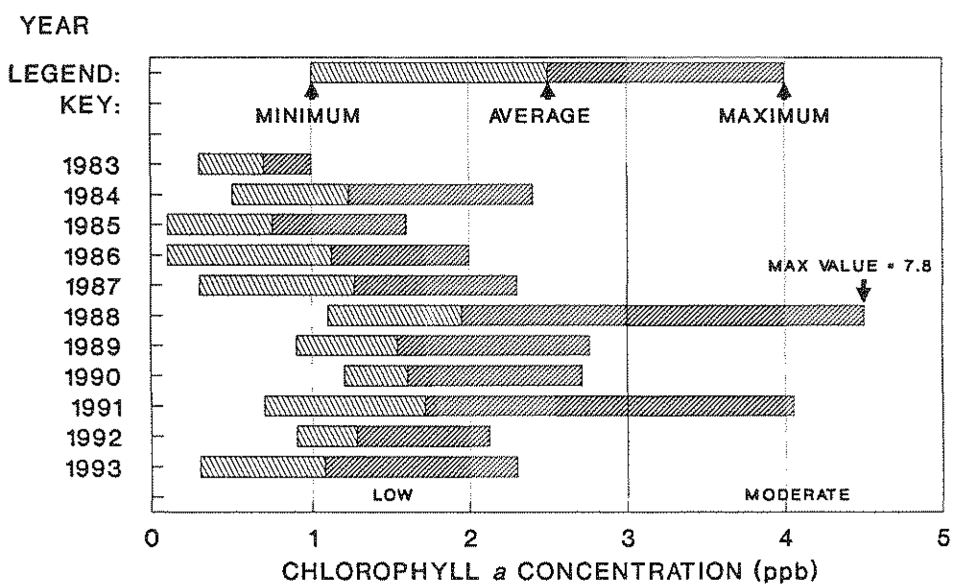
Figure 36. Silver Lake, Site 4 East. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 4 EAST
YEARLY COMPARISONS (1983-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 4 EAST
YEARLY COMPARISONS (1983-1993)

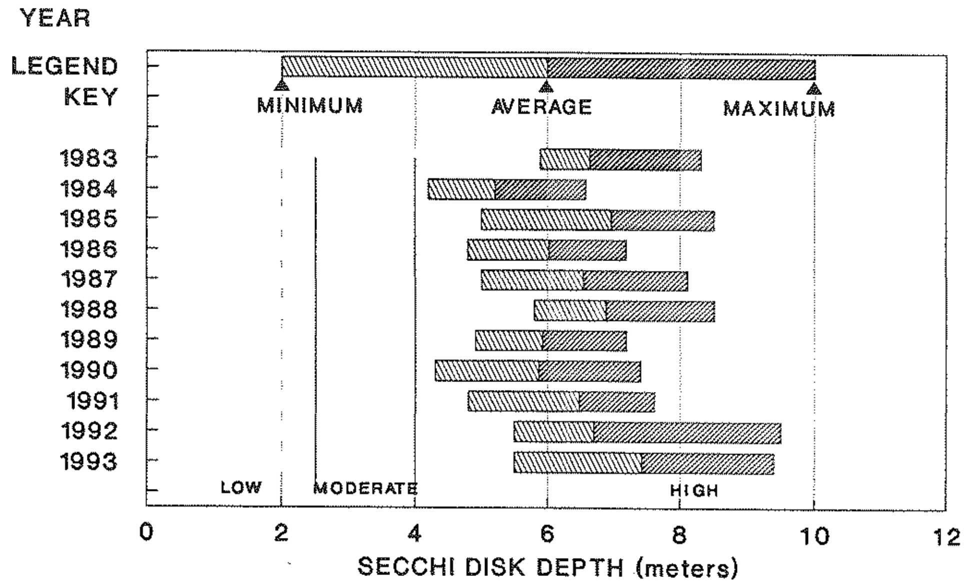


The higher value = more algal growth

Figure 37. Silver Lake, Site 5 North. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

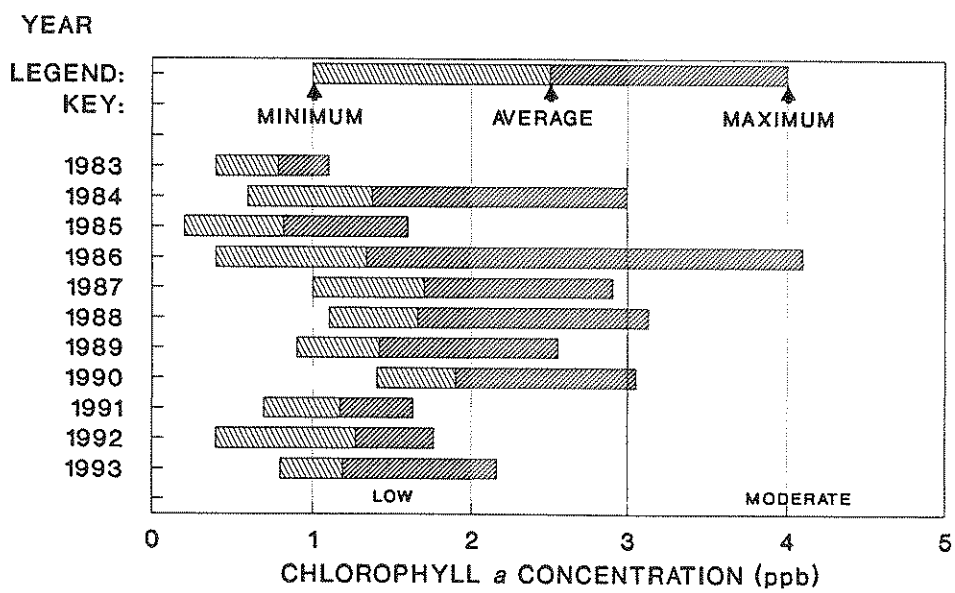
Figure 38. Silver Lake, Site 5 North. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 5 NORTH
YEARLY COMPARISONS (1983-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 5 NORTH
YEARLY COMPARISONS (1983-1993)

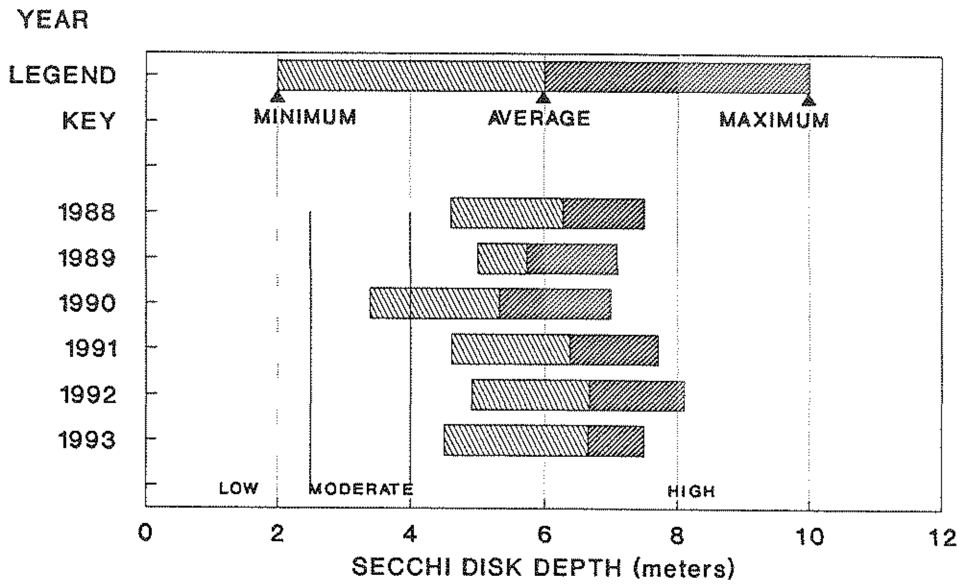


The higher value = more algal growth

Figure 39. Silver Lake, Site 7 North Island. Comparison of 1993 Secchi Disk Transparencies to previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the lake. Secchi Disk readings are taken to the nearest tenth (0.1) of a meter.

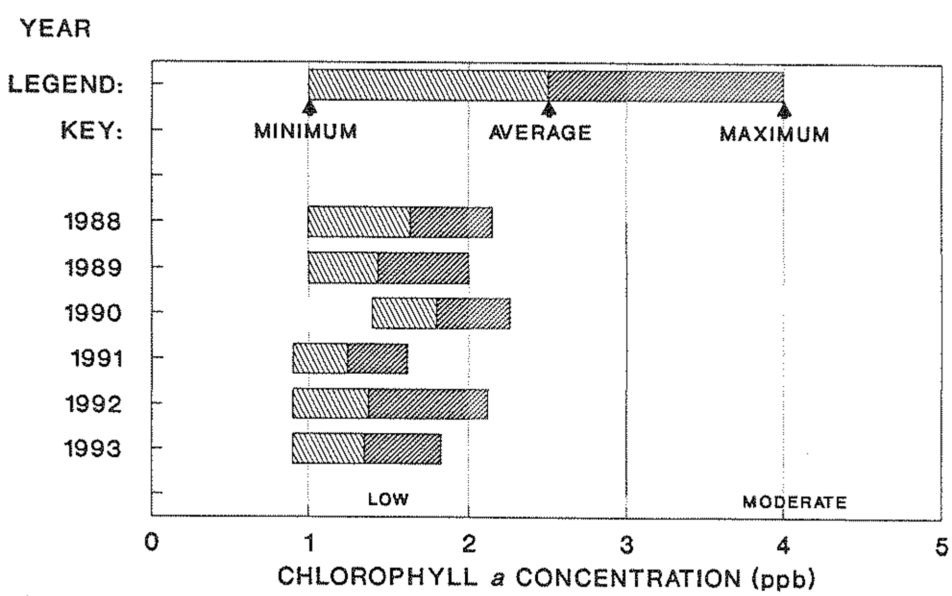
Figure 40. Silver Lake, Site 7 North Island. Comparison of 1993 Chlorophyll *a* Concentrations with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The greater the concentration of chlorophyll *a* the "greener" the lake (more algal growth).

LAY MONITOR SECCHI DISK DATA
SILVER LAKE (MADISON) - SITE 7 NORTHIS
YEARLY COMPARISONS (1988-1993)



The higher value = clearer water

LAY MONITOR CHLOROPHYLL *a* DATA
SILVER LAKE (MADISON) - SITE 7 NORTHIS
YEARLY COMPARISONS (1988-1993)



The higher value = more algal growth

Silver Lake Data on file as of 06/24/1994.

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Silver Lake, Madison, NH
-- subset of trophic indicators, all sites, 1993

1993 SUMMARY

Average transparency:	7.3	(1993:	60	values;	4.5	-	9.5 range)
Average chlorophyll:	1.1	(1993:	69	values;	0.3	-	2.3 range)
Average Lake phos.:	5.6	(1993:	15	values;	2.2	-	30.6 range)
Average alk (gray):	4.0	(1993:	62	values;	3.5	-	4.3 range)
Average alk (pink):	4.5	(1993:	62	values;	4.2	-	4.8 range)
Average color, 440:	17.4	(1993:	55	values;	9.4	-	50.7 range)
Average Trib. phos:	10.9	(1993:	2	values;	8.2	-	13.5 range)

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 South	06/25/1993	6.5	1.3	----	4.3	4.8	----
1 South	07/01/1993	6.7	0.9	----	4.1	4.6	50.7
1 South	07/14/1993	8.0	0.8	----	4.1	4.5	19.8
1 South	07/20/1993	7.3	1.0	----	4.1	4.6	19.8
1 South	07/27/1993	7.7	1.2	3.1	4.0	4.7	18.0
1 South	08/04/1993	6.8	0.6	----	4.1	4.6	18.9
1 South	08/10/1993	5.5	0.9	2.2	4.1	4.6	22.3
1 South	08/16/1993	8.5	0.9	----	4.0	4.6	----
1 South	09/01/1993	7.8	0.9	----	4.0	4.5	18.9
1 South	09/08/1993	8.7	1.4	----	----	----	13.7
1 South	09/14/1993	9.5	0.8	----	4.1	4.7	12.9
1 South	09/21/1993	9.5	1.3	----	4.0	4.5	17.2
2 Deep	06/25/1993	5.8	1.3	----	3.6	4.5	----
2 Deep	07/01/1993	7.0	1.3	3.1	3.8	4.4	18.0
2 Deep	07/14/1993	7.7	0.5	----	4.0	4.5	16.3
2 Deep	07/20/1993	8.0	0.9	----	3.9	4.2	12.0
2 Deep	07/27/1993	7.7	0.7	----	3.9	4.5	17.2
2 Deep	08/04/1993	7.8	0.6	----	4.0	4.5	15.5
2 Deep	08/10/1993	6.8	0.9	2.4	3.9	4.4	15.5
2 Deep	08/16/1993	7.5	0.9	----	4.0	4.5	----
2 Deep	09/01/1993	6.8	0.9	----	4.1	4.5	15.5
2 Deep	09/08/1993	9.0	1.0	----	----	----	12.9
2 Deep	09/21/1993	9.0	1.6	----	4.1	4.6	29.2
3 Center	04/28/1993	----	0.4	----	----	----	----
3 Center	06/25/1993	7.0	1.1	----	3.5	4.6	----
3 Center	07/01/1993	6.3	1.3	4.6	3.8	4.2	17.2
3 Center	07/14/1993	8.3	0.6	----	3.9	4.6	14.6
3 Center	07/20/1993	7.7	1.7	----	4.0	4.5	18.0
3 Center	07/27/1993	7.4	0.7	4.6	3.9	4.5	15.5
3 Center	08/04/1993	7.8	0.9	----	4.0	4.4	14.6

Silver Lake Data on file as of 06/24/1994

Site	Date	Trans-parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
3 Center	08/10/1993	5.8	1.4	4.9	3.9	4.5	13.7
3 Center	08/16/1993	6.8	0.8	----	4.0	4.5	----
3 Center	09/01/1993	8.0	0.9	----	4.0	4.6	14.6
3 Center	09/08/1993	9.0	1.1	----	----	----	15.5
3 Center	09/21/1993	9.4	1.5	----	4.0	4.6	9.4
4 East	06/25/1993	-2.0	0.3	----	3.8	4.6	----
4 East	07/01/1993	-2.0	1.2	3.3	3.9	4.5	22.3
4 East	07/14/1993	5.5	0.6	----	4.1	4.6	15.5
4 East	07/20/1993	5.5	0.9	----	3.9	4.5	17.2
4 East	07/27/1993	-2.0	2.3	----	4.0	4.5	20.6
4 East	08/04/1993	-2.0	1.1	----	4.0	4.5	17.2
4 East	08/10/1993	-2.0	0.9	4.0	3.5	4.4	25.8
4 East	08/16/1993	-2.0	0.9	----	4.0	4.6	----
4 East	09/01/1993	-2.0	1.3	----	4.2	4.7	15.5
4 East	09/08/1993	5.4	1.4	----	----	----	12.9
4 East	09/21/1993	-2.0	1.4	----	4.1	4.7	15.5
5 North	06/25/1993	5.5	2.1	----	3.9	4.5	----
5 North	07/01/1993	6.7	1.4	2.2	4.0	4.5	18.0
5 North	07/14/1993	8.1	0.8	----	4.1	4.6	11.2
5 North	07/20/1993	7.5	1.4	----	4.1	4.5	21.5
5 North	07/27/1993	7.4	0.9	----	4.0	4.6	16.3
5 North	08/04/1993	6.5	1.1	----	4.0	4.5	18.9
5 North	08/10/1993	6.0	0.9	4.0	3.9	4.4	17.2
5 North	08/16/1993	7.5	0.9	----	4.1	4.5	----
5 North	09/01/1993	7.7	1.1	----	4.0	4.6	13.7
5 North	09/08/1993	8.0	1.2	----	----	----	18.0
5 North	09/14/1993	9.4	0.8	----	4.1	4.6	18.9
5 North	09/21/1993	8.7	1.4	----	4.2	4.6	12.0
7 Hypo	07/10/1993	----	----	30.6	----	----	----
7 NorthIs	06/25/1993	6.0	1.6	----	3.9	4.7	----
7 NorthIs	07/01/1993	6.5	1.4	3.1	3.9	4.7	18.9
7 NorthIs	07/14/1993	7.1	1.1	----	3.9	4.4	16.3
7 NorthIs	07/20/1993	7.0	1.0	----	4.1	4.4	16.3
7 NorthIs	07/27/1993	7.4	1.1	6.6	4.0	4.5	----
7 NorthIs	08/04/1993	4.5	1.6	----	4.0	4.6	19.8
7 NorthIs	08/10/1993	5.3	1.2	5.1	4.0	4.5	18.0
7 NorthIs	08/16/1993	7.5	0.9	----	4.1	4.6	----
7 NorthIs	09/01/1993	7.2	1.1	----	4.2	4.6	16.3
7 NorthIs	09/08/1993	7.3	1.5	----	----	----	16.3
7 NorthIs	09/21/1993	7.4	1.8	----	4.1	4.7	12.0
8 ForestI	07/10/1993	----	----	8.2	----	----	----
8 ForestI	08/10/1993	----	----	13.5	----	----	----

<< End of 1993 listing, 72 records >>

Silver Lake - Site 2 Deep (FBG Data) August-25-1993

Depth (m)	pH	CO2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. (umho)	T-Phos (ppb)	Chloro-phyll *a* (ppb)	Diss. Color (ptu)
0-6.0	----	----	2.9	3.3	----	4.7	1.5	11.2
0.5	6.6	1.3	2.4	3.0	35.0	----	1.1	12.9
3.0	6.7	1.5	1.8	2.7	33.6	----	----	----
8.0	6.5	2.4	2.6	3.0	34.1	----	5.3	18.0
25.0	6.3	7.1	1.8	2.5	32.0	9.7	----	----

Secchi Disk Depth 8.3 meters

Depth (m)	Tem-perature (C^{O})	Diss. oxygen (mg/l)
0.10	23.1	8.3
0.50	22.9	8.2
1.00	22.9	8.2
2.00	22.8	8.2
3.00	22.7	8.2
4.00	22.7	8.2
5.00	22.3	8.3
6.00	21.9	8.5
6.50	19.7	9.3
7.00	18.0	10.0
7.50	15.4	10.8
8.00	14.0	10.4
8.50	10.6	11.9
9.00	9.6	11.7
9.50	8.5	11.4
10.00	8.1	11.4
10.50	7.8	11.2
11.00	6.9	11.0
12.00	6.3	11.0
13.00	6.0	10.7
14.00	5.8	10.6
15.00	5.7	10.5
16.00	5.7	10.5
17.00	5.7	10.4
18.00	5.5	10.5
19.00	5.5	10.6
20.00	5.3	10.6
21.00	5.1	10.8
22.00	4.9	10.8
23.00	4.8	10.8
24.00	4.7	10.6
24.50	4.7	10.6

Depth (m)	Tem-perature (C^{O})	Diss. oxygen (mg/l)
25.00	4.6	10.6
25.50	4.6	10.6
26.00	4.6	10.6
26.50	4.6	10.5
27.00	4.5	8.4

Silver Lake - Site 5 North (FBG Data) August-25-1993

Depth (m)	pH	CO2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. (umho)	T-Phos (ppb)	Chloro-phyll *a* (ppb)	Diss. Color (ptu)
0-5.5	----	----	3.0	3.4	----	6.0	1.4	13.7
0.5	6.4	1.6	3.0	3.3	35.7	----	1.4	12.9
3.0	6.8	1.8	3.1	3.5	35.0	----	----	----
8.0	6.3	3.8	2.6	3.3		----	4.8	17.2
15.0	6.3	8.2	2.1	3.0	32.9	7.7	----	----

Depth (m)	Tem-pera-ture (C^o)	Diss. oxygen (mg/l)
0.10	24.0	8.2
0.50	24.0	8.2
1.00	23.8	8.3
2.00	23.5	8.3
3.00	23.4	8.2
4.00	23.3	8.2
5.00	22.7	8.3
5.50	22.4	8.5
6.00	20.8	9.1
6.50	19.4	9.4
7.00	18.1	10.0
7.50	14.4	10.4
8.00	12.1	11.1
8.50	11.0	11.1
9.00	10.0	11.1
9.50	8.9	11.0
10.00	8.3	10.8
10.50	8.0	10.7
11.00	7.8	10.7
11.50	7.6	10.6
12.00	7.4	10.2
12.50	7.3	10.2
13.00	7.2	9.9
13.50	7.0	9.7
14.00	6.9	9.5
14.50	6.7	9.1
15.00	6.6	6.5
15.50	6.5	5.9
16.00	6.5	----

Secchi Disk Depth <u>8.5 meters</u>

Silver Lake - Site 7 North Island (FBG Data) August-25-1993

Depth (m)	pH	CO2 (mg/l)	Alk Gray end pt.	Alk Pink end pt.	Spec. Cond. (umho)	T-Phos (ppb)	Chloro-phyll *a* (ppb)	Diss. Color (ptu)
0-4.5	----	----	3.2	3.5	----	6.1	1.6	16.3
0.5	6.5	2.2	2.6	3.3	35.0	----	1.6	11.2
2.0	6.8	1.7	2.5	3.0	33.7	----	----	----
7.0	6.5	2.6	3.2	3.5	36.1	----	2.7	14.6
11.5	6.3	21.0	15.6	16.4	54.0	18.6	----	----

Depth (m)	Tem-pera-ture (C^O)	Diss. oxygen (mg/l)
0.10	24.1	8.2
0.50	24.1	8.2
1.00	24.0	8.2
2.00	23.8	8.1
3.00	23.5	8.3
4.00	23.2	8.3
4.50	22.9	----
5.00	22.4	8.1
5.50	21.6	8.5
6.00	21.0	8.8
6.50	20.1	9.2
7.00	17.0	9.9
7.50	15.5	9.7
8.00	12.8	6.4
8.50	11.5	5.4
9.00	9.4	3.5
9.50	8.4	2.6
10.00	7.6	0.1
10.50	7.2	0.2
11.00	6.9	0.2
11.50	6.8	0.2
12.00	6.5	0.2
12.50	6.5	0.3

Secchi Disk Depth 7.3 meters